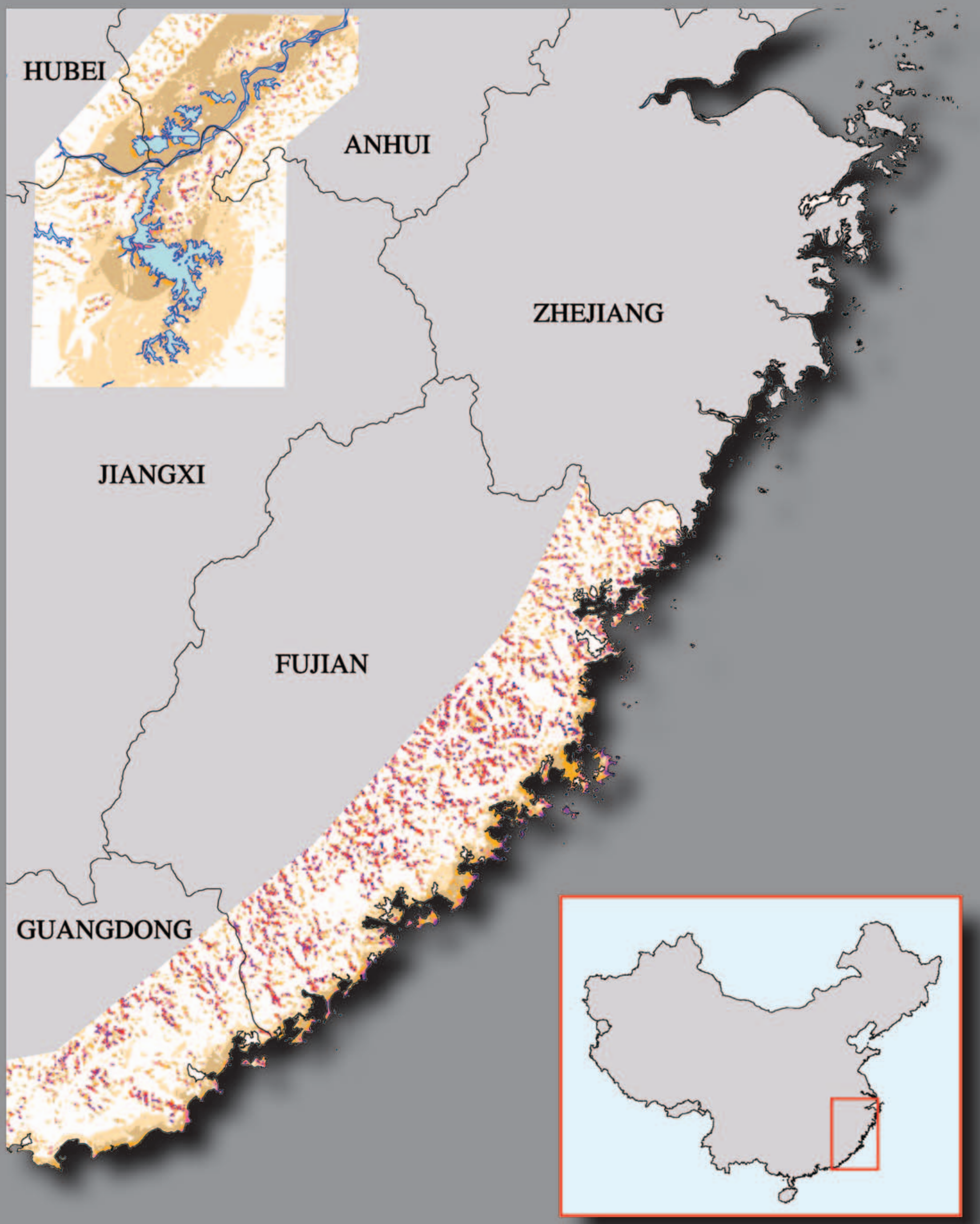
Wind Energy Resource Atlas of Southeast China



D. Elliott, M. Schwartz, G. Scott, S. Haymes, D. Heimiller, R. George
National Renewable Energy Laboratory

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D. Elliott
M. Schwartz
G. Scott
S. Haymes
D. Heimiller
R. George

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Table of Contents

List of Tables

List of Figures

Executive Summary

This wind energy resource atlas identifies the wind characteristics and distribution of the wind resource in two regions of southeast China. The first region is the coastal area stretching from northern Fujian south to eastern Guangdong and extending approximately 100 km inland. The second region is centered on the Poyang Lake area in northern Jiangxi. This region also includes parts of two other provinces—Anhui and Hubei—and extends from near Anqing in Anhui south to near Nanchang in Jiangxi.

The detailed wind resource maps and other information contained in the atlas facilitate the identification of prospective areas for use of wind energy technologies, both for utility-scale power generation and off-grid wind energy applications. We created the high-resolution (1-km^2) maps in 1998 using a computerized wind resource mapping system developed at the National Renewable Energy Laboratory (NREL). The mapping system uses software known as a Geographical Information System (GIS).

The two primary inputs to the mapping system were meteorological data and 1-km^2 gridded terrain data. The meteorological data sources include surface and upper-air data. The data were screened to select representative stations and periods of record for use in preparing inputs to the mapping system. The final meteorological inputs to the mapping system were vertical profiles of wind power, wind power roses (the percentage of total potential wind power by direction sector), and the offshore wind power where appropriate. These inputs determined the base wind power density of each grid cell. The GIS was used to adjust the base wind power density value, considering factors such as the topography in the vicinity of the grid cell and a combination of the absolute and relative elevation of the grid cell. The primary output of the mapping system was a color-coded map showing the estimated wind power and equivalent wind speed for each individual grid cell.

The wind-mapping results showed many areas that are estimated to have good-to-excellent wind resources in both the coastal region of Fujian and eastern Guangdong and the region around Poyang Lake. The most attractive areas are along the immediate coastal area and on the offshore islands, particularly along the coast of Fujian, where many high wind resource areas were identified by the mapping process. Similarly attractive areas were identified along the coast of eastern Guangdong, although these areas are less widespread than along the Fujian coast. Wind-mapping results for the Poyang Lake region also indicated many specific areas of good-to-excellent wind resources, such as well-exposed lakeshores and hilltops, particularly to the east and southeast of Lu Shan. Finally, in both the coastal and Poyang Lake regions, we identified many high mountaintop locations that are likely to possess good-to-excellent wind resources, but the steep terrain may make accessibility difficult.

The wind resource maps and other characteristic information will be useful in helping identify prospective areas for wind energy applications. However, because most of the wind resource estimates are preliminary, we strongly recommend that wind measurement programs be conducted to validate the resource estimates and to refine the wind maps and assessment methods as necessary.

1.0 Introduction

The U.S. Environmental Protection Agency (EPA), through its Environmental Technology Initiative, and the U. S. Department of Energy (DOE) sponsored a wind resource assessment project for specific regions of southeast China from 1996-98. The project was undertaken to facilitate and accelerate the large-scale use of wind energy technologies in China through wind resource assessment activities that identify areas with favorable wind resources. The American Wind Energy Association (AWEA) administered this project for the EPA. The U.S. National Renewable Energy Laboratory (NREL), in cooperation with AWEA, provided technical lead for the analysis and mapping activities. NREL's primary goal was to develop detailed wind resource maps for the specific regions of southeast China selected for the assessment. The China Hydropower Planning General Institute (CHPGI) of the State Power Corporation of China supported the project by obtaining summaries of wind data from agencies in China. In 1998, CHPGI initiated a wind measurement program in southeast China, using instrumentation supplied by AWEA with funding support from EPA. The measurement program included identification of sites, installation of measurement systems, and collection of data.

The main body of this document presents the wind resource analysis and mapping results for two specific regions of southeast China: (1) the coastal region stretching from northern Fujian south to eastern Guangdong, and (2) the Poyang Lake region, primarily in northern Jiangxi but also including parts of Anhui and Hubei. Figure 1-1 is a map of southeast China highlighting these regions.

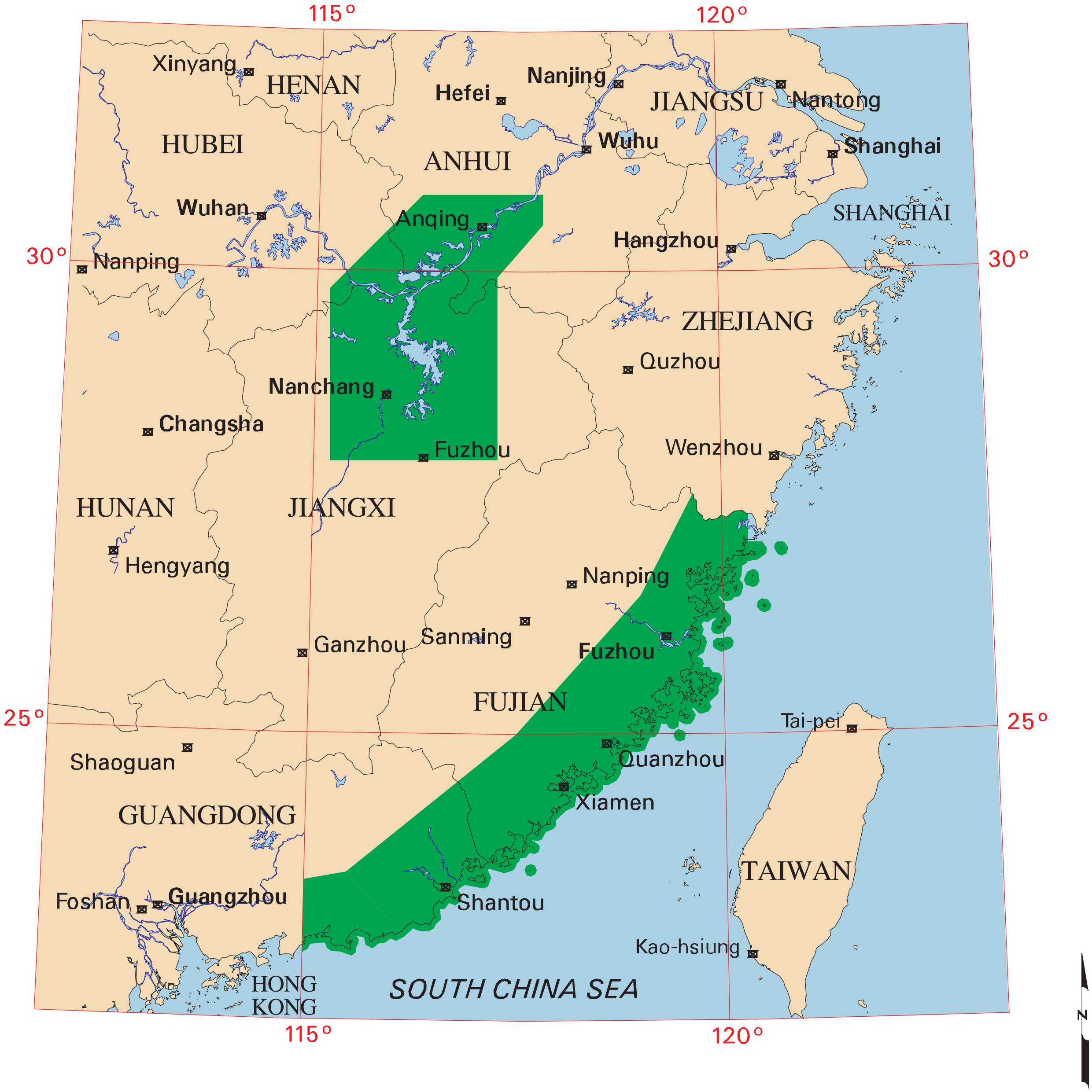
The wind resource maps were created in 1998 using a Geographic Information System (GIS)-based program developed at NREL. The mapping program combines terrain data and formatted meteorological data to produce high-resolution (1-square kilometer [km^2]) annual average wind resource maps. In addition to the wind resource maps, the document includes information on salient wind characteristics such as seasonal and diurnal variability and wind direction frequency.

Although the original report on this wind mapping study of southeast China was completed in 1998, we recently decided to formally publish the results in a wind atlas document. This atlas is the latest in a series of wind energy resource atlases and assessments produced by NREL. In addition to southeast China, NREL has applied its wind mapping system to produce wind resource assessments of the Dominican Republic (Elliott et al. 2001), Mongolia (Elliott et al. 2001), the Philippines (Elliott et al. 2001), and specific regions of Chile, Indonesia, Mexico, and the United States (Schwartz 1999, Elliott et al. 1999, Schwartz and Elliott 2001).

The report is divided into seven sections. Section 2 introduces the basic concepts used in wind resource estimation. Section 3 discusses the data sources used and the data processing and analysis approach. A description of the wind resource assessment and mapping methodology is presented in Section 4. A summary of important wind resource characteristics in southeastern China, based on an analysis of the existing data, is given in Section 5. The mapping results are presented in Section 6. Finally, an assessment of the wind electric potential of the near-coastal areas is presented in Section 7.

Two appendices are included. In the first appendix, we describe the results of a separate study performed in 1996 to characterize the wind resource potential of Nan'ao Island, a small island in eastern Guangdong in southeast China. In the second appendix, we present pertinent summaries of wind data from the wind-monitoring sites established by CHPGI from 1998 to 2000.

Southeast China: Wind Resource Mapping Areas



200 100 0 200 400 600 Kilometers

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Figure 1-1

2.0 Fundamentals of Wind Resource Estimation

2.1 Introduction

This section introduces the basic concepts of wind resource estimation.

Wind resource assessment studies can be placed into three basic categories:

- Preliminary Area Identification
- Area Wind Resource Evaluation
- Micrositing.

NREL's wind resource atlases are useful for the first two categories, but they do not contain the detailed information needed for micrositing studies. Details of micrositing and wind-monitoring programs can be found in the *Wind Resource Assessment Handbook* (NREL/AWS Scientific 1997).

2.2 Wind Speed and Direction

Wind speed is the simplest representation of the wind at a given point. Anemometers or other calibrated instruments measure wind speed. Wind speeds can be calculated as an average or expressed as an instantaneous value. Wind speed averaging intervals commonly used in resource assessment studies include one or two minutes (many historical weather observations), 10-minute (typically used in wind monitoring programs), hourly, monthly, and yearly periods. It is important to know the measurement height for a given wind speed because of the variation of wind speed with height. It is also desirable to know the exposure of a particular location to the prevailing winds because nearby obstacles such as trees and buildings can reduce the apparent wind speed.

Wind direction is measured with a wind vane, usually located at the same height as the anemometer. Knowledge of the prevailing wind direction is important in assessing the available resource. Correct alignment of the wind vane to a reference direction is important to accurately measure the wind direction. Wind direction observations at meteorological stations are often based on a 36-point compass (every 10 degrees). Some wind direction data are expressed in less precise 8-point (every 45 degrees), 12-point (every 30 degrees), or 16-point (every 22.5 degrees) intervals.

The wind direction distribution is often presented as a wind rose, a plot of frequency of occurrence by direction. Wind roses can also represent quantities such as the average speed or the percent of the available power for each direction.

2.3 Wind Speed Frequency Distribution

The wind speed frequency distribution characterizes the wind at a given location in two ways. First, the frequency distribution determines how often a given wind speed is observed at the location; it also identifies the range of wind speeds observed at that location. This analysis is often accomplished by sorting the wind speed observations into 1 m/s bins and computing the percentage in each bin. The wind speed distribution is important because sites with identical average wind speeds but different distributions can result in substantially different available wind resource. These differences can be as great as a factor of two or three.

2.4 Weibull Distribution Function

The wind speed frequency distribution in many areas can be closely approximated by the Weibull Distribution Function. The Weibull Function is defined as:

$$f(V) = (k/c)(V/c)^{k-1} \exp(-V/c)^{k}$$

where:

- $f(V)$ = the Weibull probability density function, the probability of encountering a wind speed of V m/s
- c = the Weibull scale factor, which is typically related to the average wind speed through the shape factor, expressed in m/s
- k = the Weibull shape factor, which describes the distribution of the wind speeds.

Detailed explanations of the Weibull Distribution Function and its application are available in many texts, such as that by Rohatgi and Nelson (1994).

2.5 Wind Power Density

The wind resource at a site can be roughly described by the mean wind speed; however, the wind power density provides a truer indication of a site's wind energy potential. Wind power density expresses the average wind power over one square meter. The power density is proportional to the sum of the cube of the instantaneous (or short-term average) wind speed and the air density. Due to this cubic term, two sites with the same average wind speed but different distributions can have very different wind power density values. The wind power density, in units of W/m^2, is computed by the following equation:

$$WPD = \frac{1}{2n} \sum_{i=1}^{n} \rho \cdot v_i^3$$

where:

- WPD = the wind power density in W/m^2
- n = the number of records in the averaging interval
- ρ = the air density (kg/m^3) at a particular observation time
- v_i^3 = the cube of the wind speed (m/s) at the same observation time.

This equation should only be used for individual measurement records (such as hourly and 10-minute) and not for long-term average records such as a monthly or yearly value. Using this equation with long-term averages will underestimate the wind power density because the higher-speed records that would contribute the most to the calculated wind power density value will have been smoothed out.

The air density term (kg/m^3) is dependent on temperature and pressure and can vary by 10% to 15% seasonally. If the site pressure and temperature are known, the air-density can be calculated using the following equation:

$$\rho = \frac{\mathbf{P}}{\mathbf{R \cdot T}}$$

where:

ρ = the air density in kg/m^3
P = the air pressure (Pa or N/m^2)
R = the specific gas constant for air (287 J/kg·K)
T = the air temperature in degrees Kelvin (°C+273).

If site pressure is not available, air density can be estimated as a function of site elevation (z) and temperature (T) as follows:

$$\rho = \left(\frac{\mathbf{P_0}}{\mathbf{R \cdot T}}\right)\varepsilon^{\left(\frac{-\mathbf{g \cdot z}}{\mathbf{R \cdot T}}\right)}$$

where:

ρ = the air density in kg/m^3
P_0 = the standard sea-level atmospheric pressure (101,325 Pa), or the actual sea-level adjusted pressure reading from a local airport
g = the gravitational constant (9.8 m/s^2)
z = the site elevation above sea level (m).

Substituting the numerical values for P_0, R, and g, the resulting equation is:

$$\rho = \left(\frac{\mathbf{353.05}}{\mathbf{T}}\right)\varepsilon^{-0.034\left(\frac{z}{T}\right)}$$

This air density equation can be substituted into the wind power density (WPD) equation for the determination of each instantaneous or multiple average value.

2.6 Wind Shear and the Power Law

Wind shear is a change in horizontal wind speed with height. The magnitude of the wind shear is site-specific and depends on wind direction, wind speed, and atmospheric stability. By determining the wind shear, one can extrapolate existing wind speed or wind power density data to other heights. The following form of the power law equation can be used to make these adjustments:

$$\mathbf{U = U_0 (z/z_0)^{\alpha}} \qquad \text{[Wind Speed]}$$

$$\mathbf{WPD = WPD_0\,(z/z_0)^{3\alpha}}$$ [Wind Power Density]

where:

U = the unknown wind speed at height z above ground
U_0 = the known speed at a reference height z_0
WPD = the unknown wind power density at height z above ground
WPD_0 = the known wind power density at a reference height z_0
α = the power law exponent.

An exponent of 1/7 (or 0.143), which is representative of well-exposed areas with low surface roughness, is often used to extrapolate data to higher heights.

3.0 Data Sources and Analysis

An accurate wind resource assessment is highly dependent on the quantity and quality of the input data. NREL reviewed numerous sources of wind speed data and previous wind energy assessments as part of its overall evaluation. We used several global wind data sets in the assessment, including land surface observations, marine data, and upper-air data. We also used data obtained by CHPGI from meteorological agencies and other sources in southeast China. Multiple data sets are used because the quality of data in any particular data set can vary and because high-quality data can be quite sparse in many regions of the world. Each data set plays an integral role in the overall assessment. This chapter summarizes the data sets analyzed in the wind resource mapping effort for southeastern China.

3.1 Surface Data

The following sections present a summary of the surface data sets obtained and examined in the assessment.

3.1.1 DATSAV2

This global climatic database, obtained from the U.S. National Climatic Data Center (NCDC), contains the surface weather observations from first-order meteorological stations throughout the world that transmitted data via the Global Telecommunications System (GTS). NREL used 24 years of DATSAV2 data in this project, spanning the period 1973 to 1996. Additional years of data, typically from 1957 to 1962, were available in DATSAV2 for many stations in China. Meteorological parameters, such as wind speed, wind direction, temperature, pressure, and altimeter setting, are extracted from the observations and used to create statistical summaries of wind characteristics. Most of the stations in southeast China transmitted observations every three hours during operation hours; many stations did not transmit during late night hours. At many stations, the transmission frequency changed over the years. Some stations transmitted more frequently (hourly) or less frequently (such as every six hours) during some time periods. Each station in DATSAV2 is identified by a unique six-digit number based on the World Meteorological Organization (WMO) numbering system.

3.1.2 Marine Climatic Atlas of the World

This is one of two global marine wind data sets used by NREL to provide estimates of the wind resource for offshore areas, as well as coastal and inland sites that are well exposed to the ocean winds. This data set, compiled from historical ship observations, presents summarized wind statistics for a 1°-latitude-by-1°-longitude grid. Measurements are concentrated along the major shipping routes. Included are summaries of the monthly means and standard deviations of wind speed, pressure, temperature, and wind direction frequency and speed.

3.1.3 Special Sensor Microwave Imager (SSMI)

The SSMI, which is part of the Defense Meteorological Satellite Program, provides 10-m ocean wind speed measurements. This data set provides much more uniform and detailed coverage of oceanic wind speeds than the Marine Climatic Atlas of the World. NREL used seven years of SSMI data covering the period 1988 to 1994.

3.1.4 Data from China Sources

The CHPGI provided summarized wind data for 85 selected meteorological stations in southeastern China for analysis in this study. These data, which were not included in DATSAV2, were primarily from stations in or near the two mapping regions. The data for 79 of the stations consisted of monthly mean wind speeds on a yearly basis and generally spanned the 20-year period from 1974 to 1993. The data for six of the stations consisted of hourly wind data for a one-year period.

3.2 Upper-Air Data

Upper-air data provide an estimate of the wind resource at various levels in the atmosphere and contribute to the understanding of the vertical distribution of the wind resource. This is useful in estimating the winds on elevated terrain features and for estimating the wind resource at exposed locations in areas without reliable surface wind observations. The following two upper-air data sets were employed in the assessment:

3.2.1 Automated Data Processing (ADP) Reports

This data set contains upper-air observations from rawinsonde instruments and pilot balloons for approximately 1,800 stations worldwide. Observation times include 00, 06, 12, and 18 Greenwich Mean Time (GMT). Wind information is available from the surface, from mandatory pressure levels (1,000 mb, 850 mb, 700 mb, and 500 mb), from significant pressure levels (as determined by the vertical profiles of temperature and moisture), and from specified geopotential heights above the surface. The significant pressure levels and geopotential heights are different for each upper-air observation. In this project, NREL used 24 years of ADP, spanning the period 1973 to 1996.

3.2.2 Global Gridded Upper-Air Statistics

This data set contains monthly means and standard deviations of climatic elements for the mandatory pressure levels on a 2.5-degree global grid. The data were obtained from the NCDC and cover the period 1980 to 1991. This data set is used to supplement the ADP information in areas where upper-air data are scarce.

3.3 Data Processing and Analysis

The reliability of the meteorological input data is the most important factor in creating an accurate wind resource map. An NREL paper (Schwartz and Elliott, 1997) describes the integration, analysis, and evaluation of different meteorological data sets for use in wind resource assessment. Known problems associated with observations taken at many meteorological stations around the world include a lack of information on anemometer height, exposure, hardware, maintenance history, and observational procedures. In addition, many areas of the world with the potential to have good or excellent wind resource sites have very little or no meteorological stations to provide guidance on assessing the wind magnitude and characteristics.

An analysis of the meteorological data is performed using techniques developed by NREL specifically for wind resource analysis. A comprehensive data-processing package was used to convert the surface and upper-air data to statistical summaries of the wind characteristics. To facilitate the interpretation and analysis of the wind characteristics, the summaries are portrayed as condensed graphs in a systematic format. The summaries of surface data included the interannual variability of the wind speed and wind power, the average wind speed and power on a monthly basis, the diurnal distribution of the wind resource, and the mean wind speed and frequency by direction sector. The wind power density is also computed and analyzed because it provides a truer indication of the wind resource potential than wind speed. Similar types of summaries were generated for the upper-air data, for specific geopotential heights or pressure levels of interest. Monthly and annual average vertical profiles of wind speed by geopotential height or pressure level were also generated from the upper-air data.

Site-specific products are screened for consistency and reasonableness. For example, the interannual wind speeds are evaluated to identify obvious trends in the data or periods of questionable data. Only representative data periods are selected from the entire record for use in the assessment. The summarized products are also cross-referenced against each other to select sites that have the best exposure and to develop an understanding of the wind characteristics of the study region. This is important because of the variable quality of the data and, in most cases, the lack of documentation of the anemometer height and exposure history. For assessment purposes, NREL assumes an anemometer height of 10 m (the WMO standard height) unless specific height information is provided. When there is a conflict among the information as to certain wind characteristics in the analysis region, the preponderance of meteorological evidence from the region serves as the basis of the input. The goal of the data analysis and screening process is to develop a conceptual model of the physical mechanisms, both regional and local in scale, that influence the wind flow.

4.0 Wind Resource Assessment and Mapping Methodology

The wind resource maps for the regions in southeastern China were generated using a computerized wind resource mapping system developed at NREL. This mapping system replaces the manual analysis used in previous mapping efforts conducted in the 1980s and early 1990s. An example of manual analysis is the maps in the "Wind Energy Resource Atlas of the United States" (Elliott et al. 1987). The new computerized mapping system was developed with the following two primary goals in mind: (1) to produce a more consistent and detailed analysis of the wind resource, particularly in areas of complex terrain; and (2) to generate high-quality maps on a timely basis. Examples of the application of NREL's wind mapping system in developing regional-scale wind resource maps can be found in NREL publications (Elliott and Schwartz 1997, 1998).

4.1 Description of Mapping System

The mapping system uses computerized mapping software known as Geographical Information System (GIS). The main GIS software is ArcInfo®, a powerful and complex package featuring a large number of routines for scientific analysis. None of the ArcInfo® analysis routines is specifically designed for wind resource assessment work; therefore, NREL's mapping technique requires extensive programming in ArcInfo® to create combinations of scientific routines that mimic direct wind resource assessment methods. For more information about GIS and wind energy research at NREL, refer to Heimiller and Haymes (2001).

The mapping system is divided into three main components: the input data, the wind power calculations, and the output section, which produces the final map. These components are described below.

4.1.1 Input Data

The two primary model inputs are digital terrain data and meteorological data. The elevation information consists of Digital Elevation Model (DEM) terrain data that are used to divide the analysis region into individual grid cells, each having its own unique elevation value. The United States Geological Survey and the Earth Resource Observing Satellite Data Center have produced new DEMs for most of the world from previously classified Department of Defense data and other sources. The new data sets have a resolution of 1 km^2. This represents a significant improvement in elevation data used by the mapping system, which previously relied on 1:1,000,000 scale maps and 305-m (1,000-ft) elevation contours. The final wind resource maps are gridded to 1 km^2.

Following the data-screening process, the final meteorological inputs to the mapping system are vertical profiles of wind power, wind power roses (the percentage of total wind power by direction sector), and the offshore wind power density where appropriate. The wind power density, rather than wind speed, is used because it provides a truer indication of the wind resource potential. The data are brought in as ArcInfo®-compatible files and used in the power calculation algorithms. The vertical profiles are broken down into 100-m intervals centered every 100 m above sea level (asl). The wind power rose is used to determine the degree of exposure of a particular grid cell to the power-producing winds. The offshore wind power density is derived from the SSMI and ship wind speed observations, and it is then extrapolated to 30 m for use by the model.

4.1.2 Wind Power Calculations

The wind power calculations in the mapping system are adjustments to a base wind power value derived from the meteorological input data. Factors that either decrease or increase the base wind power value for a particular grid cell are terrain considerations, relative and absolute elevation, aspect (slope of terrain relative to the prevailing wind direction), distance from ocean or lake shoreline, and the influence of small-scale wind flow patterns. Factors that have the greatest influence on the adjustment of the base wind power for a particular grid cell are the topography of the area in the vicinity and a combination of the absolute and relative elevation of the grid cell. Wind power calculation modules use the wind power rose and vertical profile of wind power in a region to account for the effects of short-range (less than 10 km), medium-range (10-50 km), and long-range (greater than 50 km) blocking of the ambient wind flow by the terrain. The slope and aspect of the terrain surrounding a particular grid cell and the relative elevation of a grid cell compared to its surroundings also affect the calculated wind power.

The wind power calculations were performed in three modules—land, ocean, and lake—depending on the existence or proximity of oceans or large lakes to the mapping region. The land module was run for the entire area only if there was no ocean present in the mapping region. Likewise, the ocean module was run for the entire area in instances in which there was an ocean shoreline present. The lake module was run only if there were lakes, estuaries, or fjords with an area of 50 km^2 or greater. This module calculated the wind power only for the area within 5 km of any non-ocean water body in the mapped region. If more than one module was run for a particular region, the results from the modules were combined to produce the final wind map. Each of the three modules contained identical routines, which use a general topographical description to adjust the base wind power density. The topographical description can be classified as either complex terrain (hills and ridges), complex terrain with large flat areas present, or areas that are designated as flat. The adjustment to the base wind power density depends on which terrain routine is activated during the mapping run.

4.1.3 Mapping Products

The primary output of the mapping system is a color-coded wind power map in units of watts per square meter (W/m^2) and equivalent mean wind speed for each individual grid cell. The wind power categories range from marginal (100 to 200 W/m^2), the lowest wind power density, to excellent (>500 W/m^2). A table of the wind power classes is provided in Section 6. Each class represents a range of mean power density or equivalent mean speed at a height of 30 m above the ground. At the time of this assessment, we chose 30 m as a compromise hub height between large utility-scale wind turbines (which may range from 30 m to 60 m and higher) and small wind turbines (which may range from 10 m to 30 m).

Wind power is calculated only for those grid cells that meet certain exposure and slope requirements. As a result, only the most favorable wind resource areas are highlighted. For example, a grid cell is excluded if there is major blocking of the ambient wind flow by local terrain features. The exposure must be at least 70% to be included. A grid cell can also be excluded if the slope of the terrain is too steep. To be included, the slope must not exceed 20%. The wind resource values presented are estimates for low surface roughness (e.g., grassland with no major obstructions such as trees or buildings). In areas of high roughness, the wind resource may be considerably less than the values shown on the maps.

The output portion of the mapping system also includes software to produce the proper map projection for the region and to label the map with useful information, such as a legend, latitude and longitude lines, locations of meteorological stations, prevailing wind direction(s), important cities, and a distance scale. The DEM data can also be used to create a color-coded elevation map, a hill-shaded relief map, and a map of the elevation contours. When combined with the wind power maps, these products enable the user to obtain a feel for the three-dimensional distribution of the wind power for the analysis region.

4.2 Limitations of Mapping Technique

There are several limitations to the mapping technique, the first of which is the resolution of the DEM data. Significant terrain variations can occur within the DEM's 1-km^2 area; thus, the wind resource estimate for a particular grid cell may not apply to all areas within the cell. A second potential problem is the development of the conceptual model of the wind flow and its extrapolation to the analysis region. Many complexities in the wind flow exist that make this an inexact methodology. Included are 1) the structure of low-level jets and their interaction with the boundary layer, and 2) localized circulations, such as land-sea breezes, mountain-valley flows, and channeling effects in areas of steeply sloped terrain. Finally, the power estimates are valid for areas with low surface roughness. Estimates for areas with a higher surface roughness need to be adjusted downward.

5.0 Wind Resource Characteristics of Southeast China

This section summarizes the wind resource distribution and characteristics of southeastern China based on analysis of the existing wind data. Representative data from specific locations or areas are generally used to evaluate and describe important aspects of the wind resource.

5.1 Meteorological Stations

5.1.1 Surface Meteorological Stations

Figure 5-1 presents the geographical distribution of meteorological stations with surface wind data that were included in the DATSAV2 data set and had at least 10,000 observations. A total of approximately 150 stations in southeastern China had wind speed data, and approximately 30 of these stations were located within the two regions covered in the wind mapping. The stations were primarily located in cities and urban areas, although some of the stations are located in sparsely populated areas, such as on mountaintops or small offshore islands. Few of the data are from airport locations.

Figure 5-2, the elevation map of the region, depicts the same meteorological stations, but it also includes additional meteorological stations provided by the CHPGI. These additional data comprised approximately 85 stations, including more than 50 in the two regions covered in the wind mapping. Fairly good data coverage is found throughout southeastern China, with a slightly higher concentration of available data along the more densely populated coastal areas. Figure 5-3 presents a shaded relief map of southeastern China, including the locations of surface wind speed data.

Information on anemometer height, location, and station history was not available. The anemometer heights at all stations were, therefore, assumed to be close to 10 m, the standard anemometer height of the WMO.

5.1.2 Upper-Air Meteorological Stations

Figure 5-4 presents the locations of the meteorological stations containing upper-air observations that were included in the ADP upper-air data set. Data coverage is fairly uniform throughout southeastern China. A total of 37 stations in southeast China had upper-air data. Twelve of these stations are located within or near the two regions covered in the wind mapping. The ADP data were processed to generate various summaries of the wind characteristics for a number of pressure levels and/or height levels (where available) from the surface through 700 millibar (mb), or approximately 3000 m.

5.2 Quality of Surface and Upper-Air Data

A visual inspection of the surface plots generated by NREL enabled a quick assessment of the various characteristics of the wind resource over the analysis area. The inspection was also used to identify trends or peculiarities in the observational data. For example, the data from Pingtan station, located on an island off the coast of Fujian, provides a good example of a clear trend in the surface wind speed data. Figure 5-5 presents the yearly average wind speeds and wind powers at Pingtan station for the period 1957 to 1996, excluding the years 1965-1972, which were not available in DATSAV2. A fairly steady downward trend in mean speeds is apparent, ranging from nearly 8 m/s at the start of the period to less than 5 m/s by the end of the period. The wind power trend indicates a steeper decline over the period because wind power is a function of the cube of the wind speed. The average wind power decreased from more than 500 W/m^2 in the earliest part of the period to less than 150 W/m^2 in the latest part of the period. An analysis of the interannual data from meteorological stations throughout southeast China verified that this "disappearing wind syndrome" is widespread and occurs at all but a few stations. For example, the data in Figure 5-6 are from the 79 meteorological stations provided by CHPGI and show the ratio of wind power in each year relative to that in 1994, the first year of data. The downward trend in the data indicates that the apparent wind power in southeast China decreases by 60% in 20 years. However, the decrease is most likely caused by new construction around the meteorological stations and possibly degradation of the measurement equipment, which reduces the measured wind speeds. The few stations at which downward trends were not observed are primarily located on remote offshore islands or mountaintops away from urban areas.

We analyzed the surface station time-series plots in an effort to select periods that were considered to be most representative of the wind resource at each particular station. Subjectively choosing the representative period of record from each station can prove difficult. The inter-annual plots were screened for number of observations, trends in the wind speed and wind power density, abnormally windy or calm periods, and any abrupt changes in wind speed and power.

The upper-air wind data were screened using a process similar to that for the surface data. Additional factors considered in evaluating the quality of the upper-air data included the type of observations (rawinsonde or pilot balloon) and the amount of observations available from significant levels.

5.3 Wind Resource Distribution and Characteristics

5.3.1 Annual Wind Resource Distribution

The wind resource over southeastern China varies considerably and is strongly dependent on several key factors: topography, elevation, proximity to a large body of water, and exposure to the prevailing winds. The highest wind resource areas are found on exposed coastal and offshore island locations, as well as exposed ridge crests and mountaintops.

A sharp gradient in mean wind speed and wind power density is observed in the coastal area. Mean speeds increase from 2 m/s at low-elevation sites, 50 km inland from the coast, to greater than 5 m/s at exposed locations near the coast. The highest speeds are found at well-exposed sites on coastal peninsulas and offshore islands. Examples of stations with mean wind speeds of 7 to 8 m/s (during the most representative years) include Taishan, Mazu, Pingtan, and Jin-jiang. The mean wind power densities at these stations were in the range of 400 to 600 W/m^2.

Figures 5-6 and 5-7 show the mean annual wind speeds and wind power densities for offshore areas, based largely on the SSMI satellite data computed from data collected between 1988 and 1994. These data were valid for a height of 10-m above the ocean surface. For areas off the coast of Fujian and eastern Guangdong, mean annual speeds largely in the range of 7 to 8 m/s were measured from off the coast of extreme eastern Guangdong north to northern Fujian. The highest mean speeds of 7.5 to 8 m/s were found in the strait of Taiwan off the coast of central Fujian. Mean speeds of generally 6.5 to 7 m/s were measured off the coast of eastern Guangdong and extreme northern Fujian. Mean annual wind power densities were mostly in the range of 400 to

500 W/m^2, except for values over 500 W/m^2 in the highest resource areas off central Fujian and values of 300 to 400 W/m^2 off eastern Guangdong and northern Fujian, and some areas of 200 to 200 W/m^2 off northern Fujian.

The magnitude of the wind resource on ridge crests and mountaintops is strongly influenced by the site's exposure or its position relative to surrounding ridges or mountains. Examples of mountaintop observations include Qixian Shan, located on the border of Fujian and Jiangxi, which had a mean wind speed of 3.7 m/s, and Dehusjiuxian Mountain in Fujian, which had an annual mean speed of approximately 7 m/s.

5.3.2 Diurnal Wind Speed Distribution

The region's diurnal wind speed distribution, or wind speed versus time of day, is influenced by several factors, including site elevation and proximity to a large body of water. The distribution at low-elevation, inland sites in simple terrain typically reveals a maximum speed during the afternoon and a minimum near sunrise. The primary forcing mechanism for this pattern is the daytime heating, which destabilizes the lower levels of the atmosphere, resulting in a downward transfer of momentum to the surface. The near-surface winds tend to peak in the early afternoon, which corresponds to the time of maximum heating. In the late afternoon and evening, the declining supply of sunshine leads to surface cooling and a decrease in momentum transfer from aloft. Surface winds begin to decelerate while winds aloft tend to increase. The minimum in surface wind speed near sunrise corresponds to the time of maximum atmospheric stability.

Mountaintop diurnal distributions differ from those of low-elevation sites. The strongest winds at mountain locations occur at night, while the lowest wind speeds are observed during the midday hours. For example, the annual and monthly diurnal wind speed distributions for Lu Shan station, located at an elevation of 1165-m on a mountain in the northern section of Jiangxi Province, exhibit a well-defined maximum late at night and a minimum during the mid-afternoon. Over the ocean, wind speeds reach a maximum at night and a minimum in the afternoon, although the magnitude of the diurnal variation is usually quite small (less than 2 m/s). Diurnal wind speed changes are more complicated on the near-shore islands. The time and amplitude of the speed variation varies, depending on the distance from the coast and the size of the island. The diurnal variations for exposed coastal and island sites are usually smaller than those observed inland.

The magnitude of the diurnal variation changes with the season. The smallest diurnal variations in the wind resource are often observed during the winter months when synoptic weather systems are strongest and insolation is at a minimum. Diurnal variations are largest in the summer under a weaker synoptic regime and strong insolation.

5.3.3 Wind Direction Frequency Distribution

The majority of stations in the coastal region of southeastern China exhibit a bimodal distribution of wind direction. This distribution is a result of monsoon flows that dominate the wind patterns. The positioning of the cold Mongolian high-pressure system during the winter months and topographic channeling through the Taiwan Strait results in a strong wind flow from the northeast in the coastal regions. The high weakens with the change of seasons, and the region falls under the influence of the summer monsoon. The prevailing winds under the summer monsoon regime are from the southwest. The summer monsoon normally makes its first appearance in early May, reaches maximum intensity in July, and disappears by early September. The prevailing wind direction under the monsoon regime ranges from south-southeast to southwest.

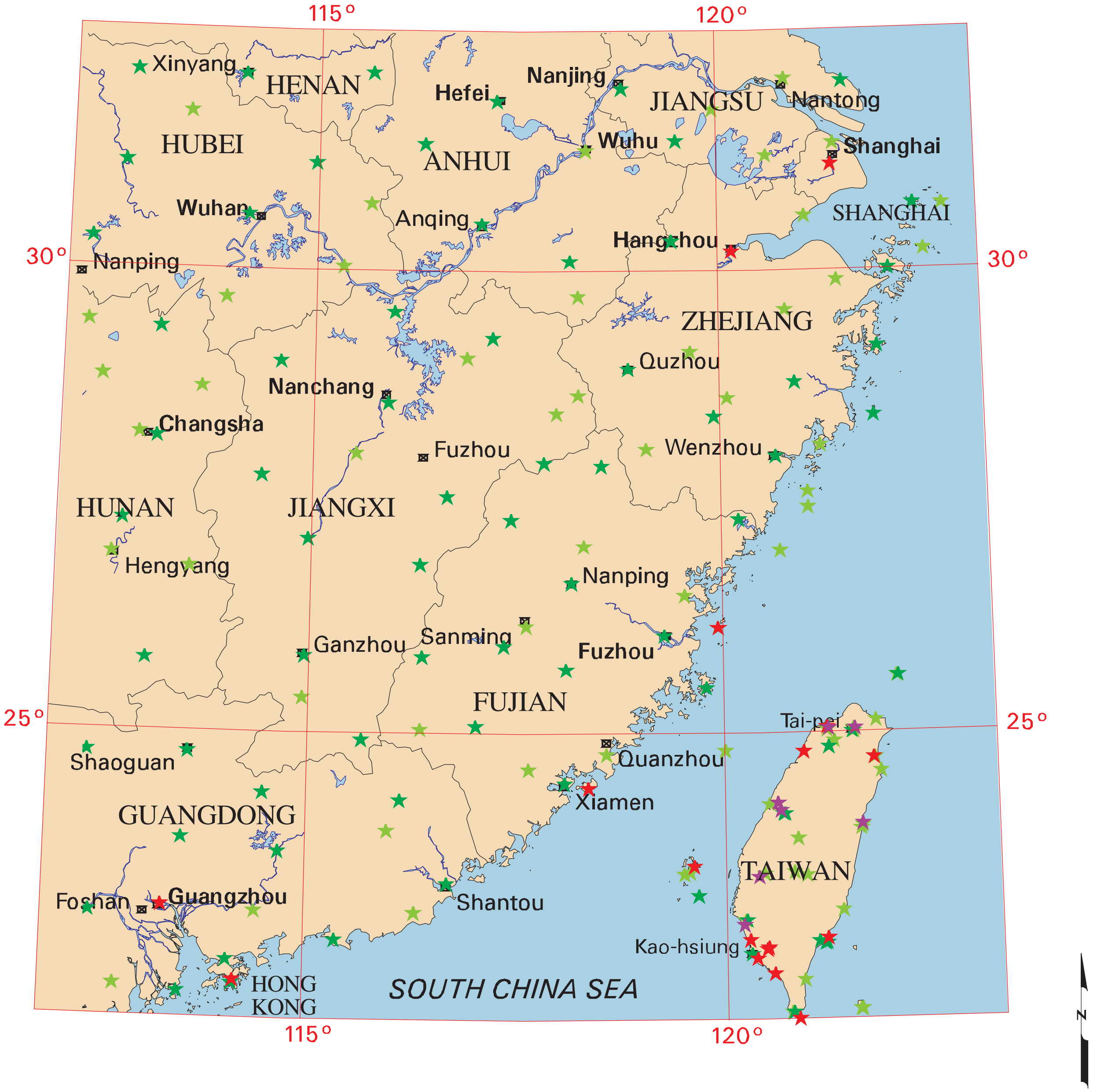
Data from stations in the Poyang Lake region also exhibit a bimodal distribution of wind direction, but the summer monsoon influence is weaker and shorter than in the coastal region. The strength and direction of the winter monsoon flow in this region is influenced considerably by the topographic channeling (see Figure 5-9 for an elevation map of the region). At Anqing, in southwest Anhui, the prevailing wind direction is northeast (roughly parallel to the orientation of the valley), whereas it is more northerly in the vicinity of Poyang Lake and at Nanchang. The strongest winds are estimated to be around the northern areas of Poyang Lake, to the east and southeast of Lu Shan, where topographic channeling appears to be the greatest.

5.3.4 Seasonal Wind Speed Distribution

On a seasonal basis, the highest mean wind speeds over southeastern China are found during the autumn and winter months. These are the seasons when gradients in temperature and pressure are the greatest. The lowest mean wind speeds occur from late spring through the summer months. Figure 5-10 presents the monthly mean wind speed and wind power density at Pingtan station, located along the coast of Fujian, for the period 1973–1978. The months with the highest wind resources are October and November. Wind speeds gradually decrease as winter progresses into spring. The strong fall and winter winds are a result of the prevailing northeasterly flow and a funneling effect of the wind between the mainland and Taiwan. The months with the lowest wind resources at Pingtan station are between April and August. During the summer months, the region is under the influence of the summer monsoon, and wind speeds are generally lighter.

Figure 5-11 presents the location of six defined wind speed regions used to compute wind speed statistics for comparison purposes. The data are from satellite-based ocean wind measurements for the period 1988–1994. The monthly average wind speed and wind power density for each region is depicted in Figures 5-12 and 5-13, respectively. The highest wind resources occur during the fall and winter, while the lowest wind resources occur during the summer. Overall, Region 4, which is in the Strait of Taiwan off the central coast of Fujian, had the highest wind resource on an annual basis, and also the highest wind resource from autumn to mid-winter. Region 6, off the extreme northern coast of Fujian, exhibits the smallest seasonal variability in the wind resource.

Southeast China - Meteorological Stations With Surface Wind Data



Meteorological Stations
Total Observations

- 200,000 to 300,000
- 100,000 to 200,000
- 50,000 to 100,000
- 10,000 to 50,000

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The Global Telecommunication System (GTS) surface meteorological stations are part of NREL's global database.

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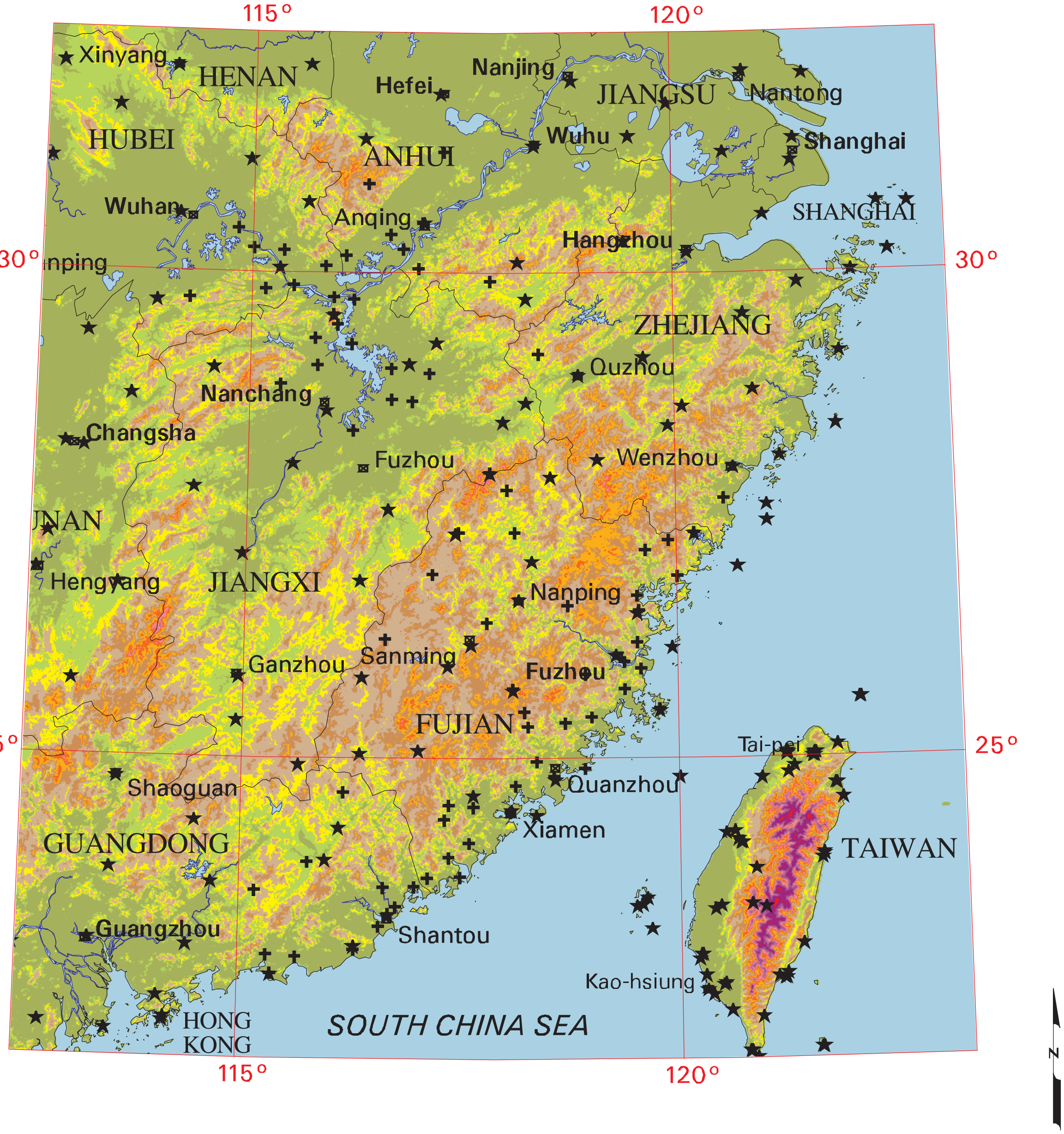
Figure 5-1

Southeast China - Elevation Map



Elevation
Meters

3800
3100
2400
2100
1800
1200
900
600
300
200
100
0

The Global Telecommunications System (GTS) meteorological stations are part of NREL's global database. The data for the additional meteorological stations were provided by the China Hydropower Planning General Institute.

Legend

★ GTS Meteorological Station with Wind Data
✚ Additional Meteorological Station with Wind Data
⊠ City

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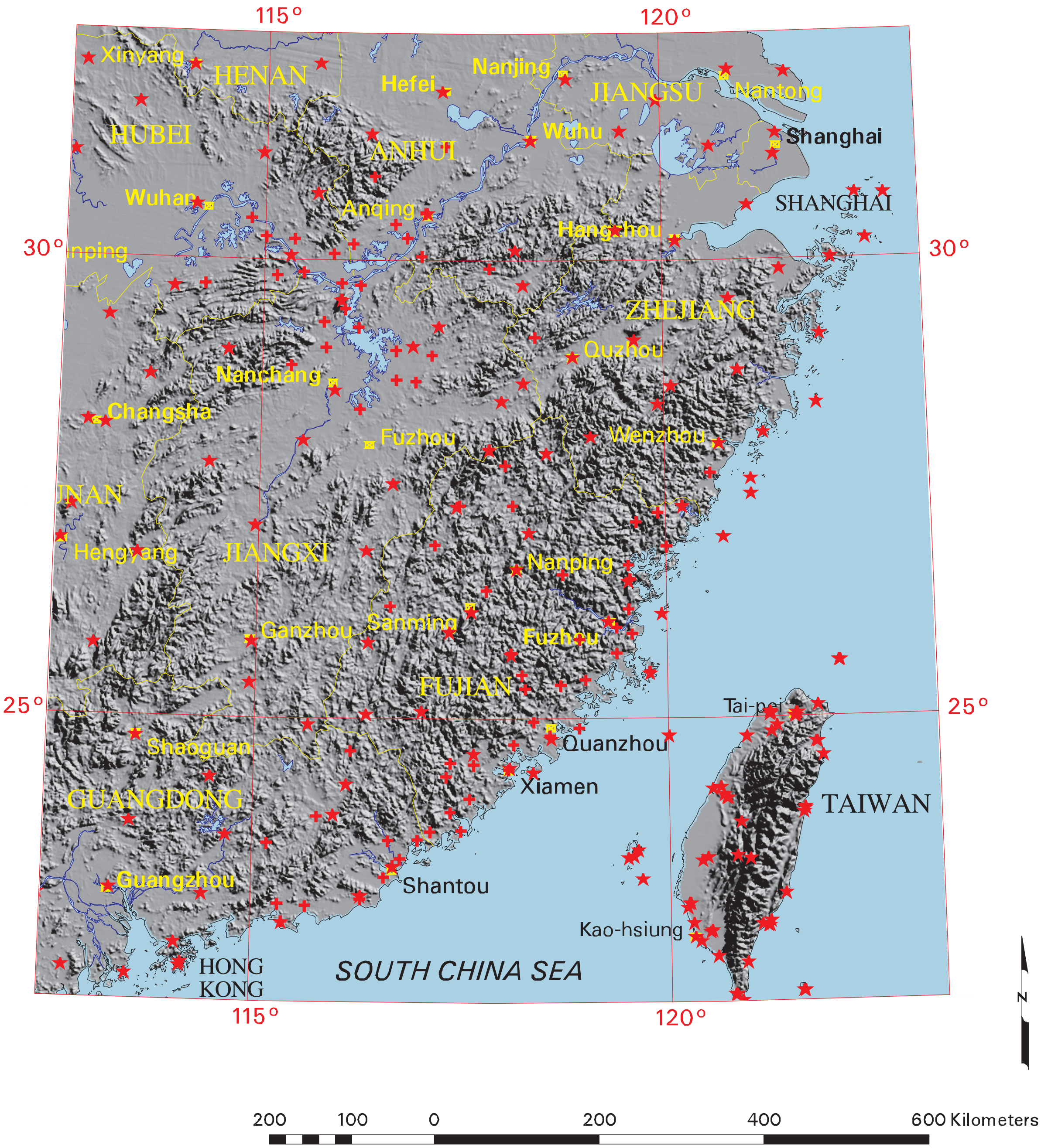
Figure 5-2

Southeast China - Hillshaded Relief Map



The Global Telecommunications System (GTS) meteorological stations are part of NREL's global database. The data for the additional meteorological stations were provided by the China Hydropower Planning General Institute.

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Legend

★ GTS Meteorological Station with Wind Data
✚ Additional Meteorological Station with Wind Data
⊠ City

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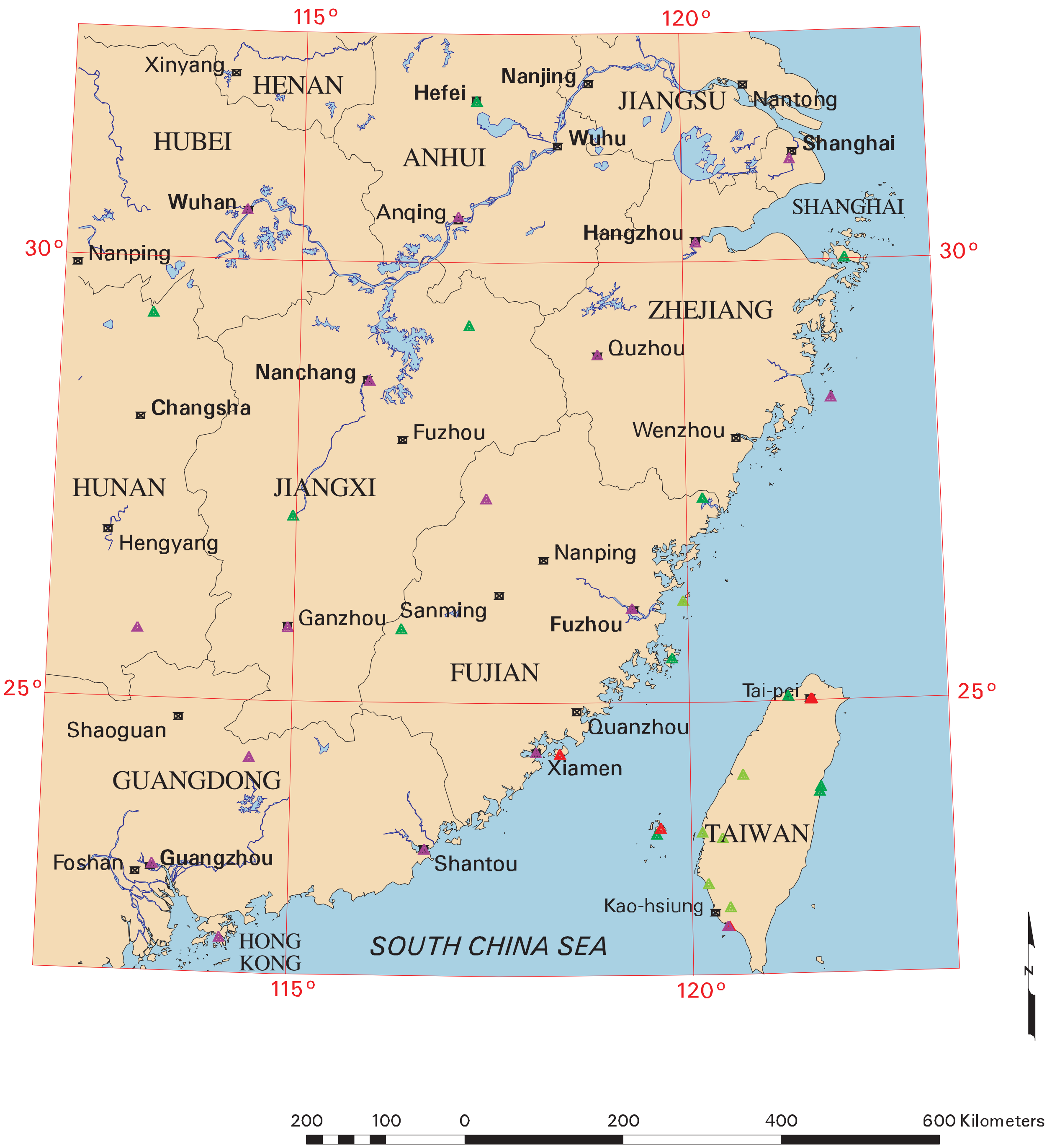
Figure 5-3

Southeast China - Meteorological Stations With Upper Air Wind Data



Meteorological Stations
Total Observations

- greater than 12,000
- 8,000 to 12,000
- 4,000 to 8,000
- less than 4,000

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The Global Telecommunication System (GTS) upper-air (weather-balloon) stations are part of the NREL's global database.

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Figure 5-4

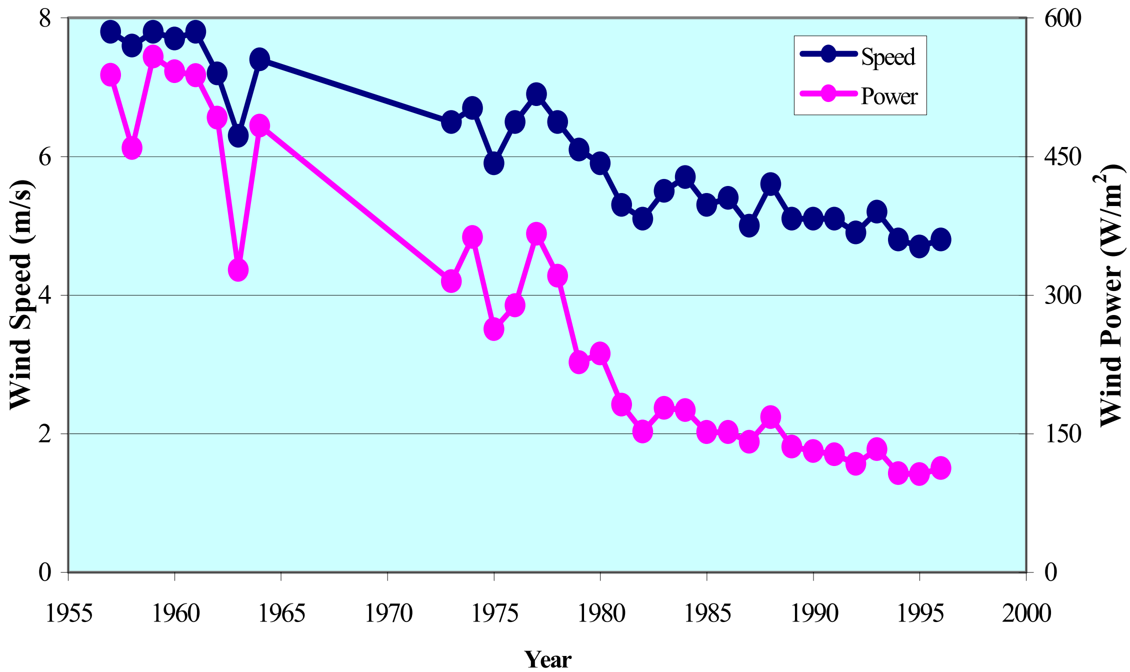

Figure 5-5: Pingtan, China – wind speed and power by year.

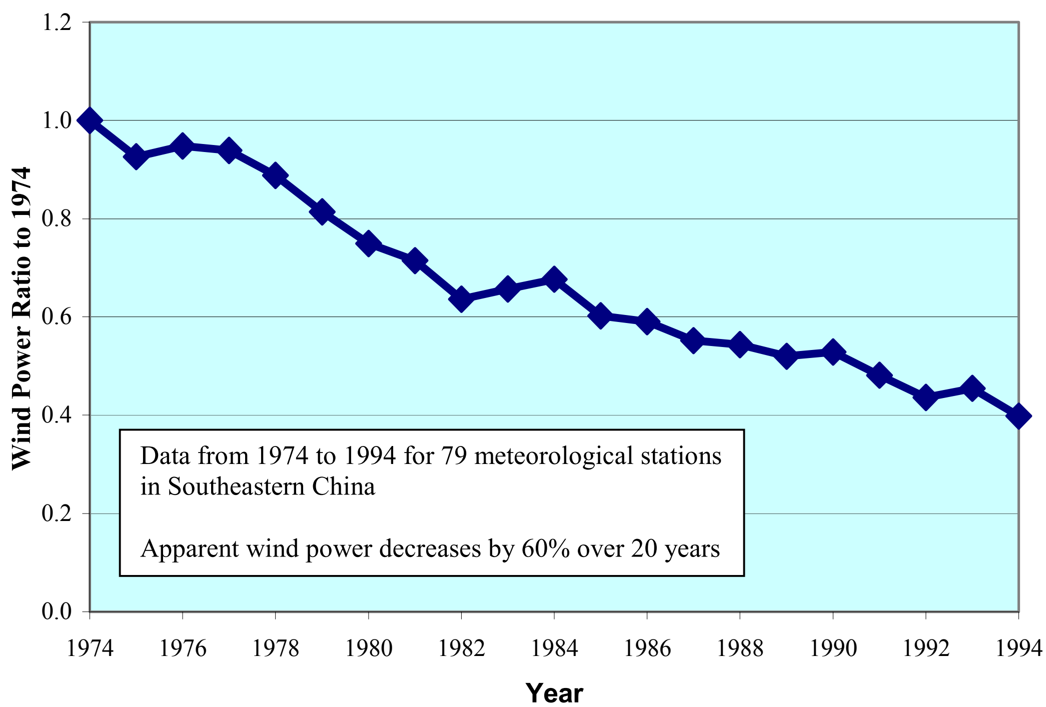

Figure 5-6: "Disappearing wind" caused by construction around meteorological stations.

Southeast China
Annual, 1988 to 1994 - Wind Speed
Computed from Satellite Ocean Wind Measurements

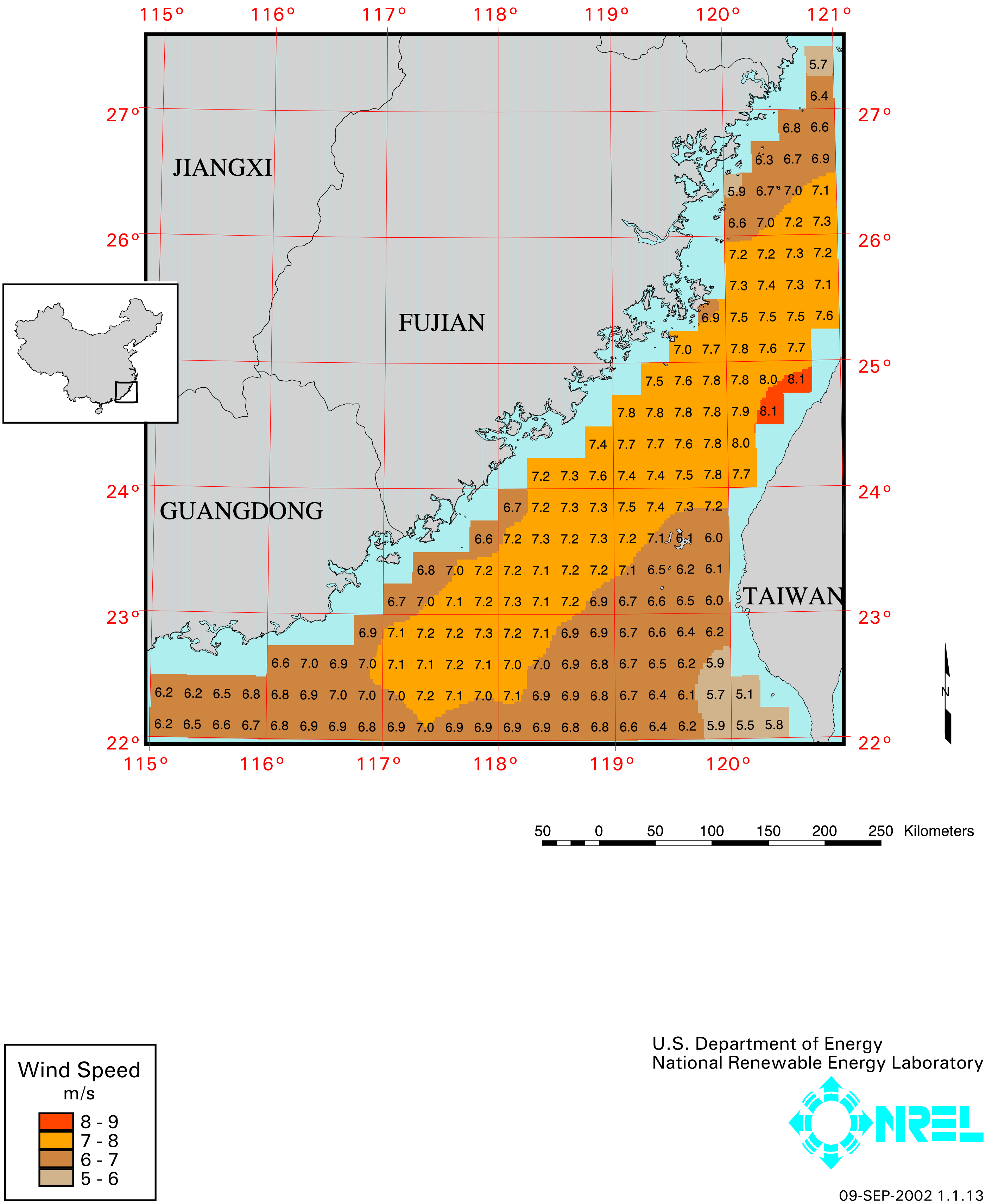

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Figure 5-7

Southeast China
Annual, 1988 to 1994 - Wind Power Density
Computed from Satellite Ocean Wind Measurements

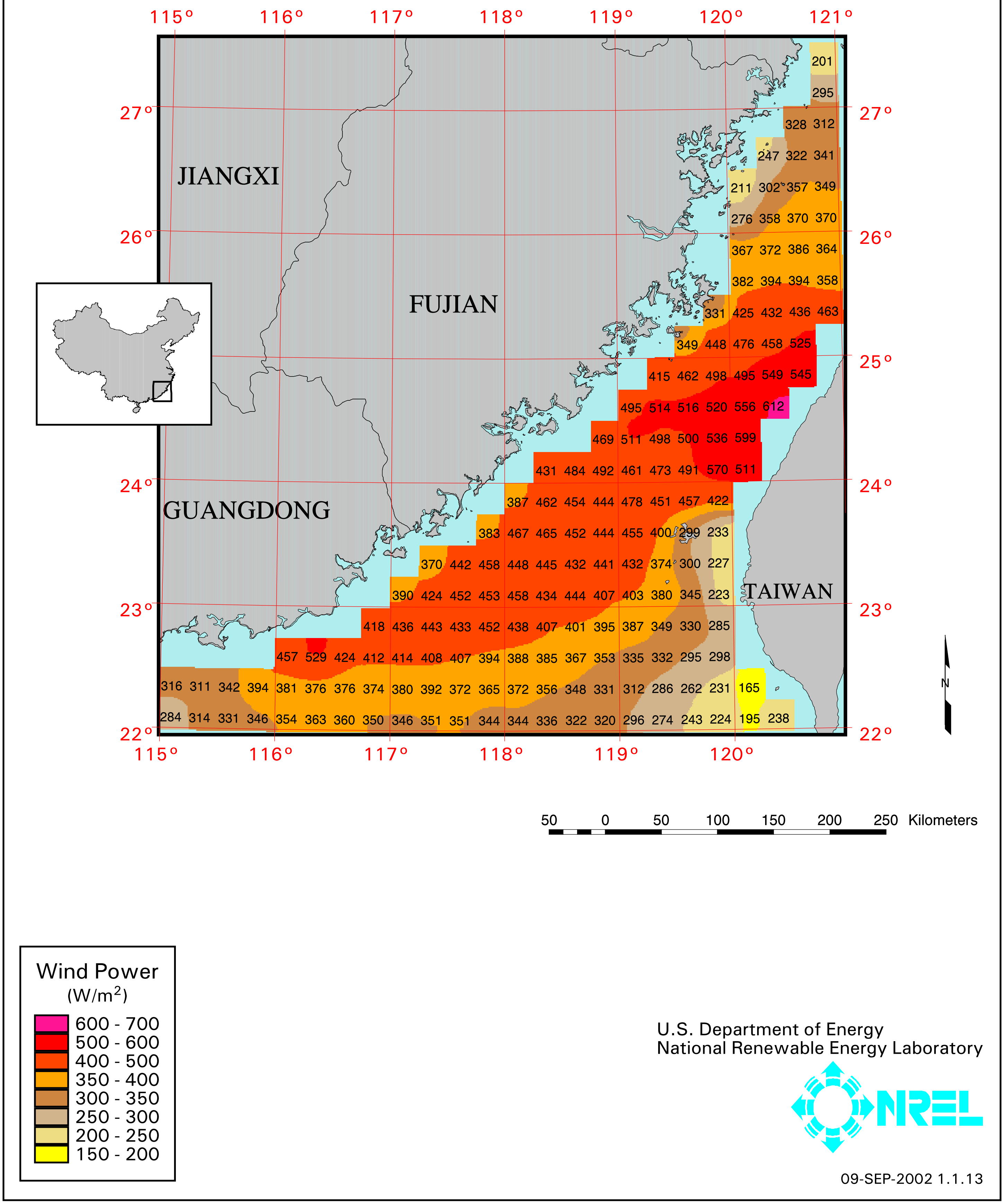
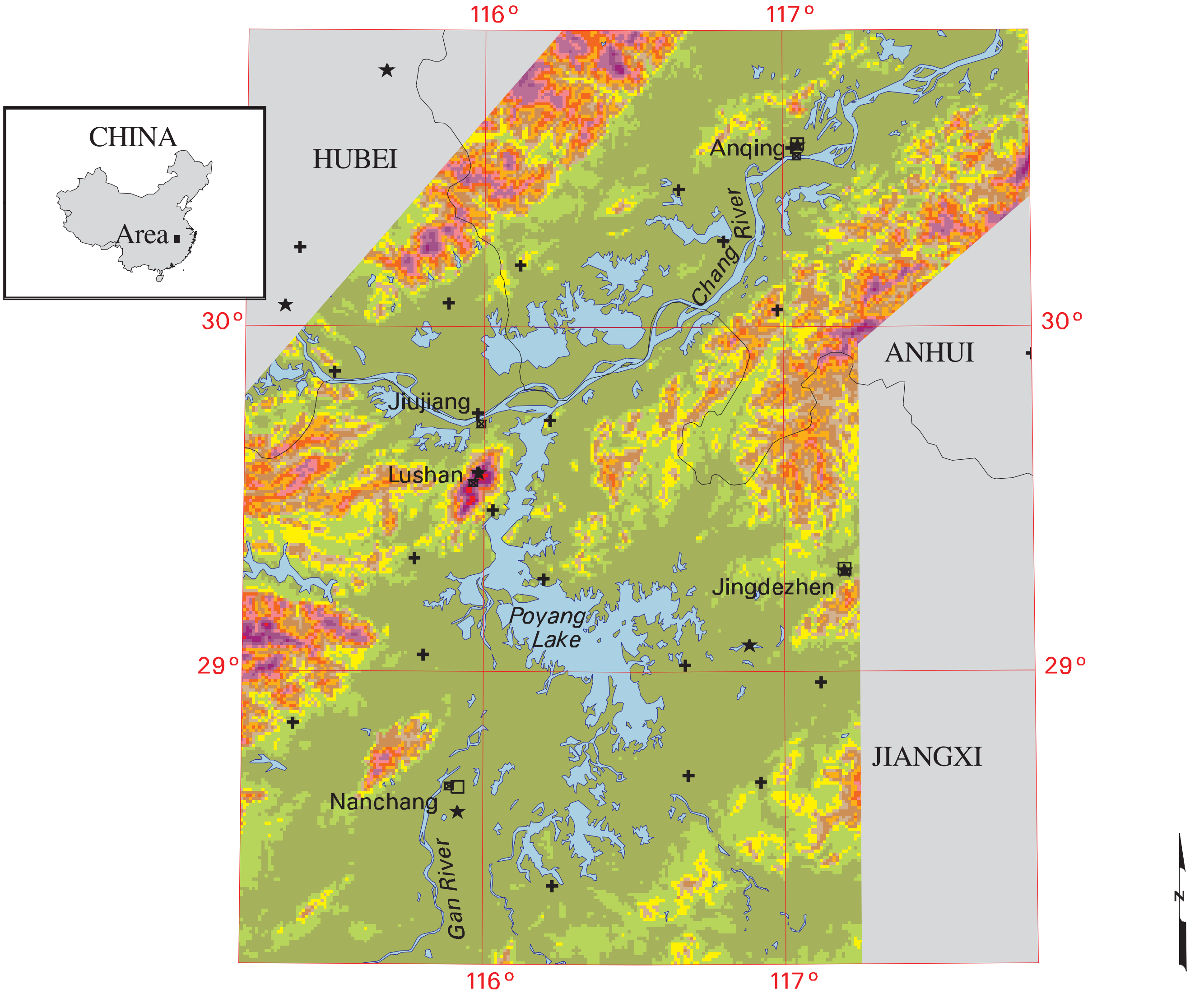


Figure 5-8

Poyang Lake Area of China
Elevation Map



Elevation
Meters

1550
1200
1000
800
600
500
400
300
200
150
100
50
0

★ GTS Surface Meteorological Station
□ GTS Upper-Air Meteorological Station
✚ Additional Surface Meteorological Station
⊠ City

The Global Telecommunications System (GTS) meteorological stations are part of NREL's global database. The data for the additional meteorological stations were provided by the China Hydropower Planning General Institute.

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09-SEP-2002 1.4

Figure 5-9

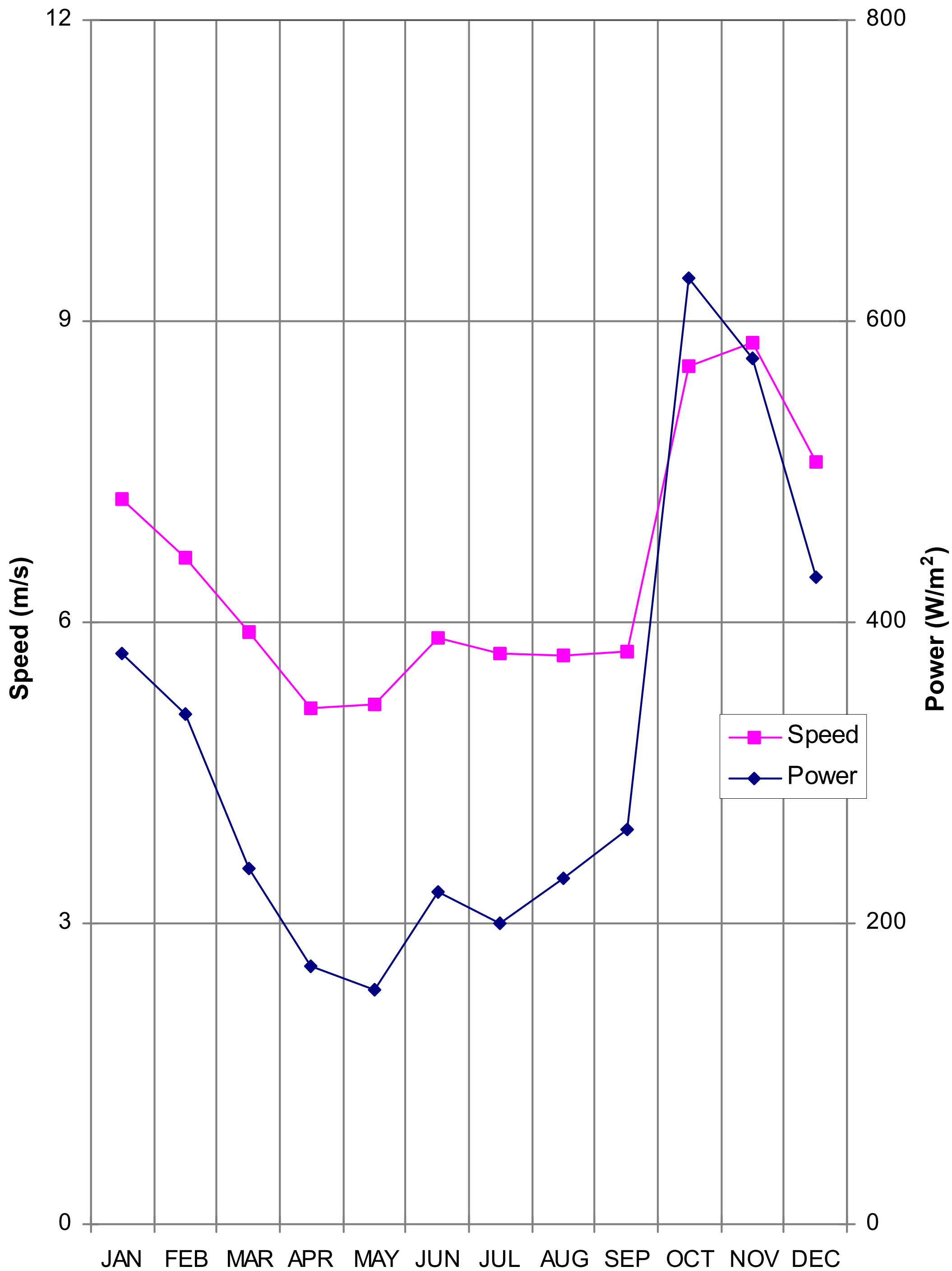

Figure 5-10: Pingtan – wind speed and power by month.

Southeast China
Region Location Map
For Satellite Ocean Wind Measurements

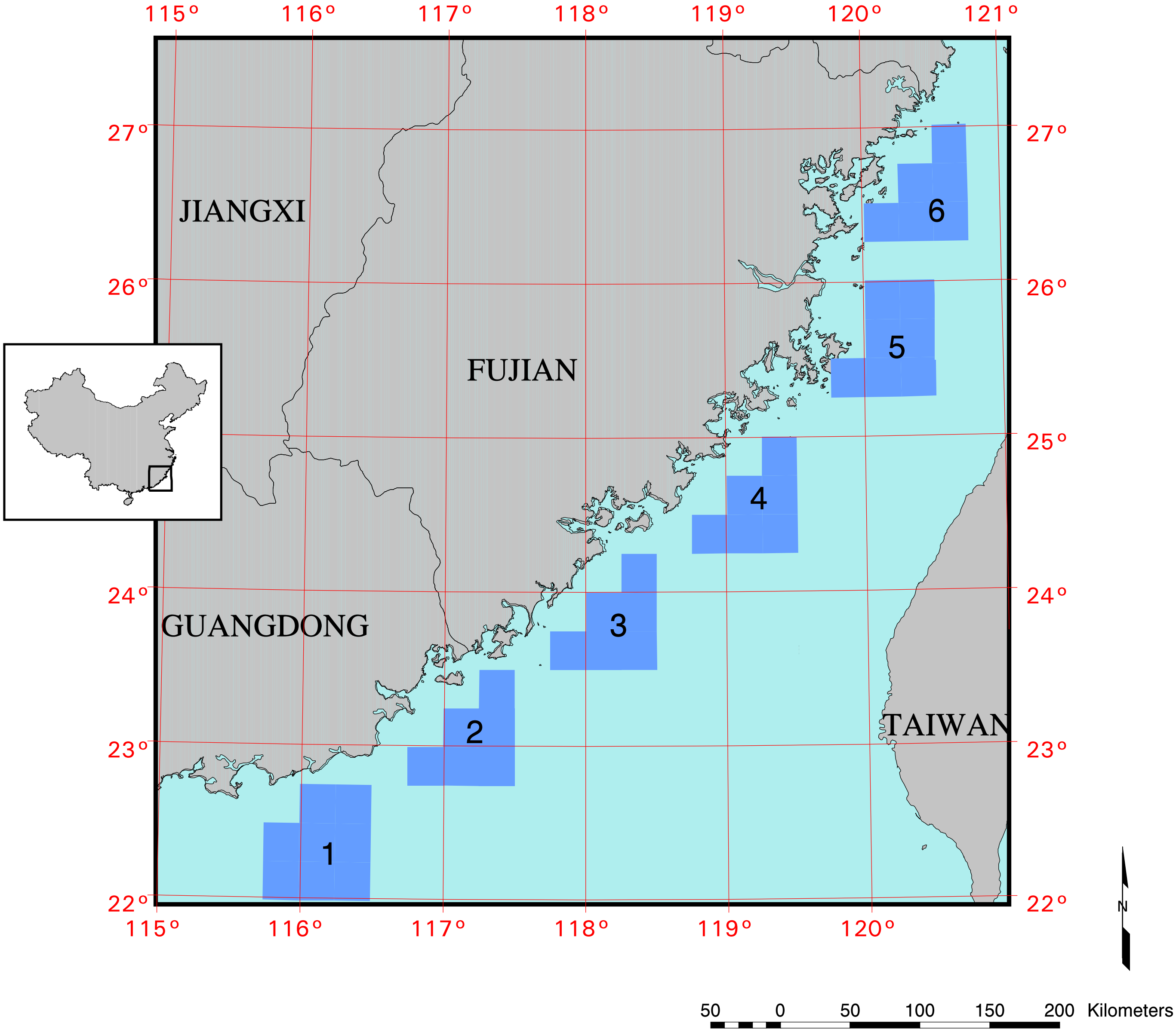

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Figure 5-11

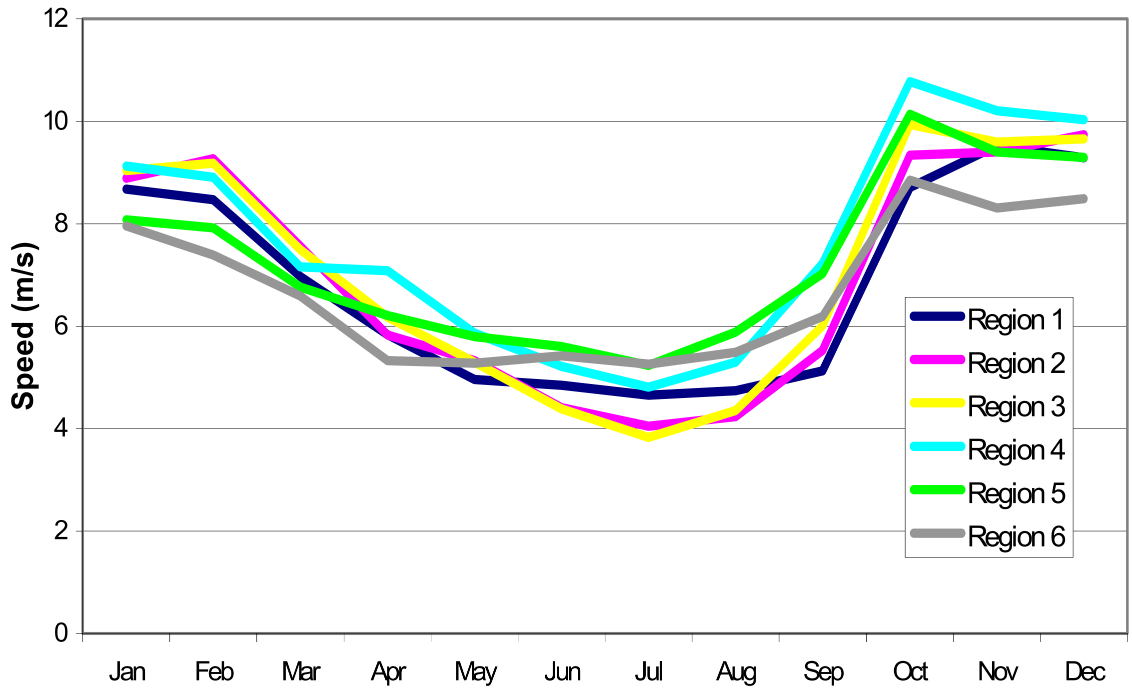


Figure 5-12: Southeast China – monthly average wind speed – 1988 to 1994 computed from satellite ocean wind measurements.

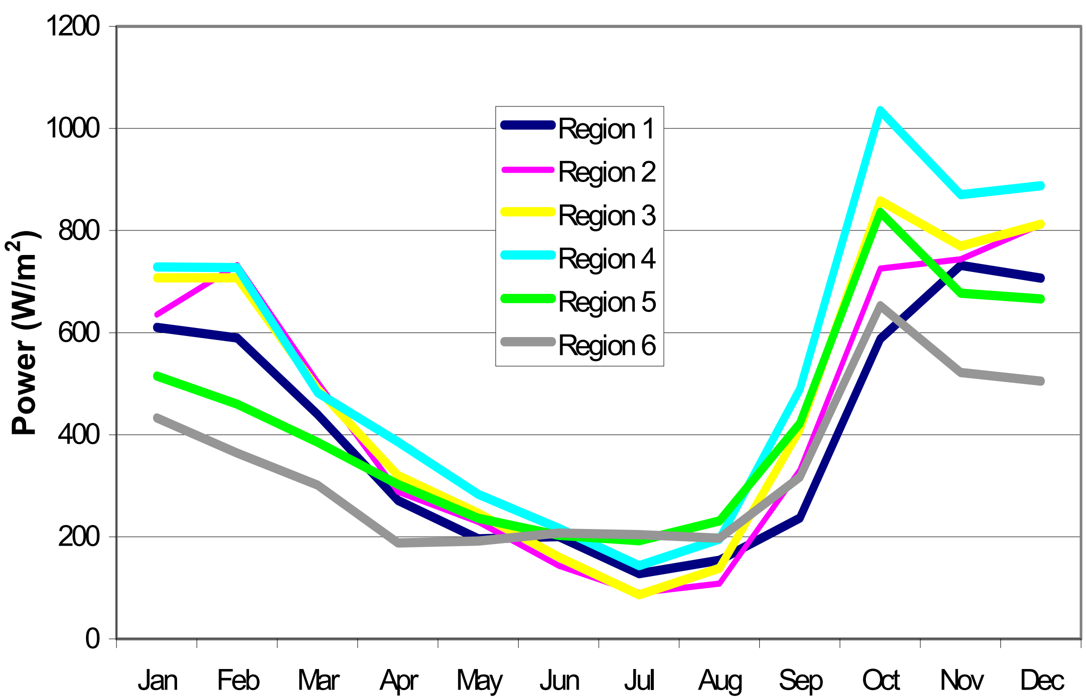


Figure 5-13: Southeast China – monthly average wind power – 1988 to 1994 computed from satellite ocean wind measurements.

6.0 Wind Resource Mapping Results for Southeast China

This section presents the wind-resource mapping results for southeast China. The maps are designed to highlight areas possessing a favorable wind resource where specific wind energy projects are likely to be feasible. Each map indicates the estimated wind resource potential, wind power density, and wind speed at 30 m above ground level.

Two distinct regions were mapped. The first region was the coastal and near-coastal area stretching from northern Fujian south to eastern Guangdong. The second region was centered on the Poyang Lake area of northern Jiangxi Province. This region included parts of three provinces—Anhui, Hubei, and Jiangxi—and extended from near Anqing in Anhui south to near Nanchang in Jiangxi.

6.1 Wind Power Classification

The wind power classification for southeast China is presented in Table 6.1. The classification used in the analysis is for utility-scale applications and applies to areas with low surface roughness. For areas with high roughness, such as trees or buildings, the wind resource may be reduced considerably. In general, locations with an annual wind power density of greater than 300 W/m^2 (6.4 m/s) are the most suitable for utility grid-connected wind energy systems. Off-grid and rural power applications may be viable at locations with lower power density values, 200 W/m^2 (5.6 m/s) and higher.

Table 6.1: Wind Power Classification

Class	Resource Potential	Wind Power Density (W/m^2) @ 30 m agl	Wind Speed [a] (m/s) @ 30 m agl
1	Marginal	100 – 200	4.4 – 5.6
2	Moderate	200 – 300	5.6 – 6.4
3	Good	300 – 400	6.4 – 7.0
4	Good	400 – 500	7.0 – 7.5
5	Excellent	500 – 700	7.5 – 8.4
6	Excellent	700 – 1000	8.4 – 9.6
7	Excellent	> 1000	> 9.6

[a] Mean wind speed is estimated assuming a sea level elevation and a Weibull distribution of wind speeds with a shape factor (k) of 2.0. The actual mean wind speed may differ from these estimated values by as much as 20%, depending on the actual wind speed distribution (or Weibull k value) and elevation above sea level.

6.2 Coastal Region Composite—Fujian and Eastern Guangdong

Figure 6-1 is the composite wind resource map for the entire coastal region of Fujian and eastern Guangdong. We divided the map into four sections to more easily depict the details of the wind resource distribution. The estimated wind resource potential in this and all other wind resource maps in this section is indicated using a color-coded scheme. The wind resource classification applies to areas with low surface roughness. Areas in white represent areas of low wind resource (<100 W/m^2) or grid cells that did not meet certain exposure or slope requirements as described in Section 4.1.3.

6.3 Northern Coast of Fujian

Figure 6-2 presents a map of favorable wind resource areas along the northern coast of Fujian. The coastline is irregular and hilly, particularly to the north of Lianjiang, with a number of peninsulas extending out from the mainland and many islands. Many areas were identified that are estimated to have a good-to-excellent wind resource. These include the three large peninsulas to the northeast, east, and southeast of Louyuan. Although the well-exposed ridgetops in the coastal areas are estimated to have an excellent wind resource, much of the coastline near sea level is estimated to have only a low-to-moderate wind resource because of the sheltering effects of the complex coastal terrain. However, some exposed low-elevation areas along the coast (such as the large peninsula to the east-southeast of Fuzhou) and offshore islands are estimated to have good wind resource potential. Although the percentage of attractive area is greater near the coast, there are many inland ridgetops estimated to have a good-to-excellent wind resource. They are well exposed and oriented roughly perpendicular to the prevailing wind directions. This orientation tends to produce an acceleration of the wind as it approaches and passes over these features.

6.4 Central Coast of Fujian

Figure 6-3 presents a map of favorable wind resource areas for the central coast of Fujian, covering the region between Xiamen to just south of Fuzhou. Figure 6-4 shows the wind resource map combined with a shaded relief map, which enables the user to better relate the wind resource patterns to specific terrain features. The coastline of central Fujian is complex, containing several large bays, islands, and land areas protruding into the ocean. A number of very attractive areas are identified along the immediate coastline. The wind resource along the immediate coastline ranges from fair to excellent, the most promising areas being well exposed to the northeasterly wind direction and not strongly influenced by upwind terrain features. The most attractive wind resource regions include the eastward extension of land areas to the southeast and east-northeast of Quanzhou, islands directly east of Xiamen, the peninsulas to the southeast of Putian and to the west of Pingtan, and the island of Haitan (on which Pingtan is located). In northern Fujian, there are many inland ridgetops estimated to have good-to-excellent wind resource. However, the coastal areas are expected to be more suitable for large-scale wind energy development than the inland ridgetops because the coastal areas are generally more accessible and closer to large population centers and electrical grid systems.

6.5 Southern Coast of Fujian and Eastern Coast of Guangdong

Figure 6-5 depicts the favorable wind resource areas along the southern coast of Fujian and the extreme eastern coast of Guangdong. As in central and northern Fujian, the coastline in this region is complex, containing several large bays, peninsulas, and islands. There are many exposed coastal areas estimated to possess a good wind resource, with some locations expected to have an excellent wind resource. Notable attractive features include the well-exposed cape just to the south of Xiamen, the several peninsulas and exposed shorelines to the southwest of Fotan, and the island of Nan'ao to the east-northeast of Shantou. As in central and northern Fujian, there are many inland ridgetops estimated to have a good-to-excellent wind resource.

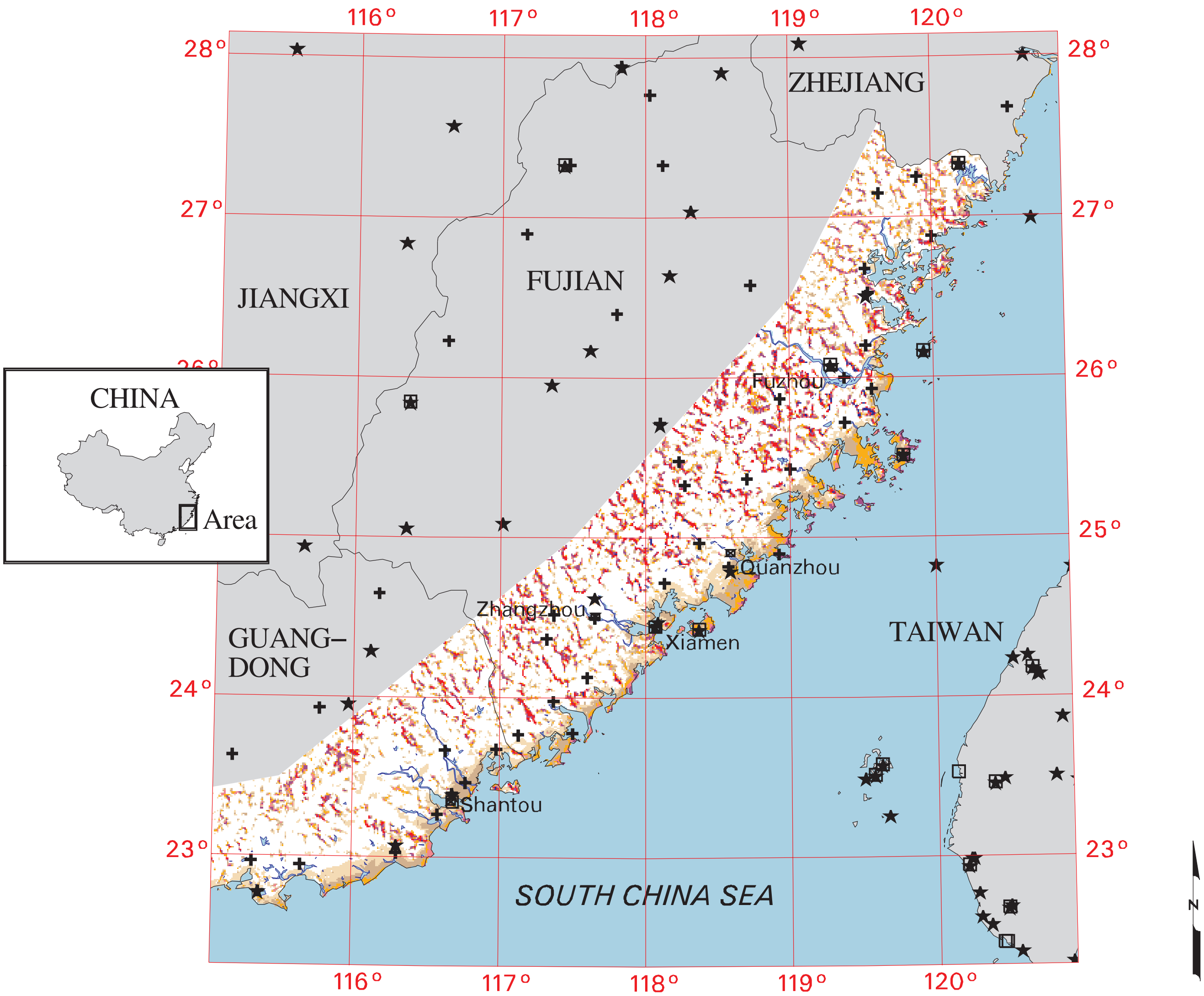
6.6 Eastern Coast of Guangdong

The locations of favorable wind resource areas on the eastern coast of Guangdong are displayed in Figure 6-6. Although there are a number of areas estimated to have a good wind resource, and a few specific locations with an excellent resource, the coastal areas estimated to have good-to-excellent resources are less widespread than coastal areas farther north. This is due to the east-west coastline orientation, especially in the southern part of the region. This orientation forces the prevailing northeast winds to have an overland trajectory in many coastal areas. An overland trajectory results in lower wind speeds than an over-water trajectory. The largest percentage of good wind resource is along the immediate coastline, primarily along the eastern shores of capes and peninsulas. The most promising areas include the peninsula southeast of Shantou (including the town of Guangao) and the exposed coastal area to the east of Huilai. Scattered ridgelines with an estimated good-to-excellent wind resource were identified within the interior.

6.7 Poyang Lake Region

The map of favorable wind resource areas in the Poyang Lake region is presented in Figure 6-7 and combined with a shaded relief map in Figure 6-8. A large portion of the broad valley, stretching from north of Anquing to Jiujiang and southward to near Nanchang, is estimated to possess a moderate wind resource. Some of the best areas with good-to-excellent wind resource include the lakeshores, hilltops, and low ridges that are exposed to the prevailing northeasterly winds. The highest wind resource is estimated to occur over an area to the east and southeast of Lu Shan, where the prevailing northeasterly winds are channeled and accelerated by the topographic influences. Many of the exposed hilltops and ridges in this area are estimated to have an excellent wind resource. Some of the high mountaintop locations, such as Lu Shan (the highest mountain within this mapping region), are likely to possess a good-to-excellent wind resource, but accessibility may be difficult to many of these mountaintop locations due to the steep terrain.

Southeast China - Coastal Fujian and Eastern Guangdong
Map of Favorable Wind Resource Areas



Wind Power Classification

Resource Potential	Wind Power Density at 30 m W/m2	Wind Speed [a] at 30 m m/s
Marginal	100 - 200	4.4 - 5.6
Moderate	200 - 300	5.6 - 6.4
Good	300 - 400	6.4 - 7.0
	400 - 500	7.0 - 7.5
Excellent	500 - 700	7.5 - 8.4
	700 - 1000	8.4 - 9.6
	> 1000	> 9.6

[a] Wind speeds are based on a Weibull k value of 2.0 estimated for many coastal areas of SE China.

★ GTS Surface Meteorological Station
□ GTS Upper-Air Meteorological Station
✚ Additional Surface Meteorological Station
⊠ City

The wind resource classification is for utility scale applications and applies to areas with low surface roughness. The Global Telecommunications System (GTS) meteorological stations are part of NREL's global database. The data for the additional wind measurement sites were provided by the China Hydropower Planning General Institute.

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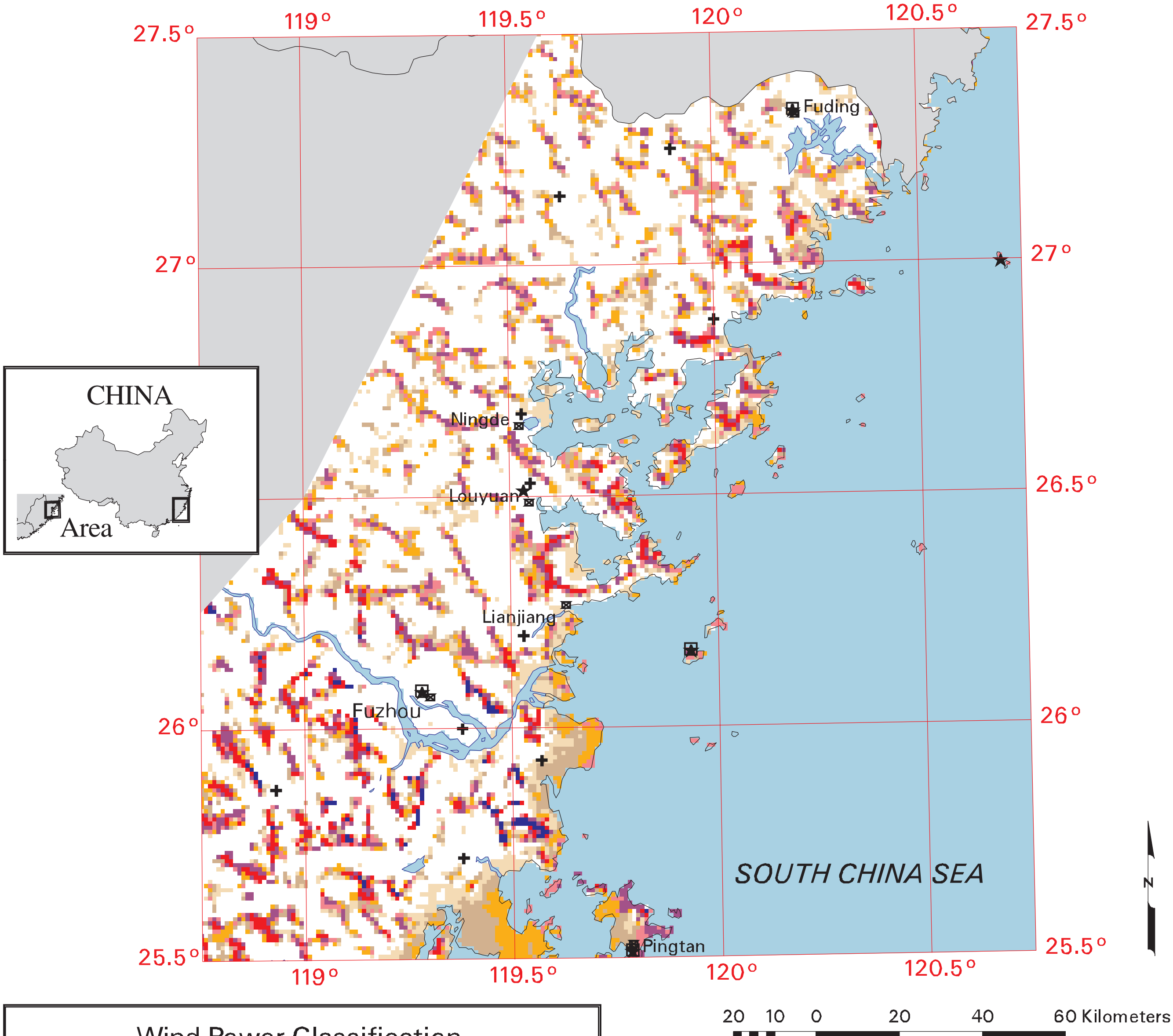
Figure 6-1

Southeast China - Northern Coast of Fujian
Map of Favorable Wind Resource Areas



Wind Power Classification

	Resource Potential	Wind Power Density at 30 m W/m^2	Wind Speed [a] at 30 m m/s
	Marginal	100 - 200	4.4 - 5.6
	Moderate	200 - 300	5.6 - 6.4
	Good	300 - 400	6.4 - 7.0
		400 - 500	7.0 - 7.5
	Excellent	500 - 700	7.5 - 8.4
		700 - 1000	8.4 - 9.6
		> 1000	> 9.6

[a] Wind speeds are based on a Weibull k value of 2.0 estimated for many coastal areas of SE China.

- ★ GTS Surface Meteorological Station
- ☐ GTS Upper-Air Meteorological Station
- ✚ Additional Surface Meteorological Station
- ⊠ City

The wind resource classification is for utility scale applications and applies to areas with low surface roughness. The Global Telecommunications System (GTS) meteorological stations are part of NREL's global database. The data for the additional wind measurement sites were provided by the China Hydropower Planning General Institute.

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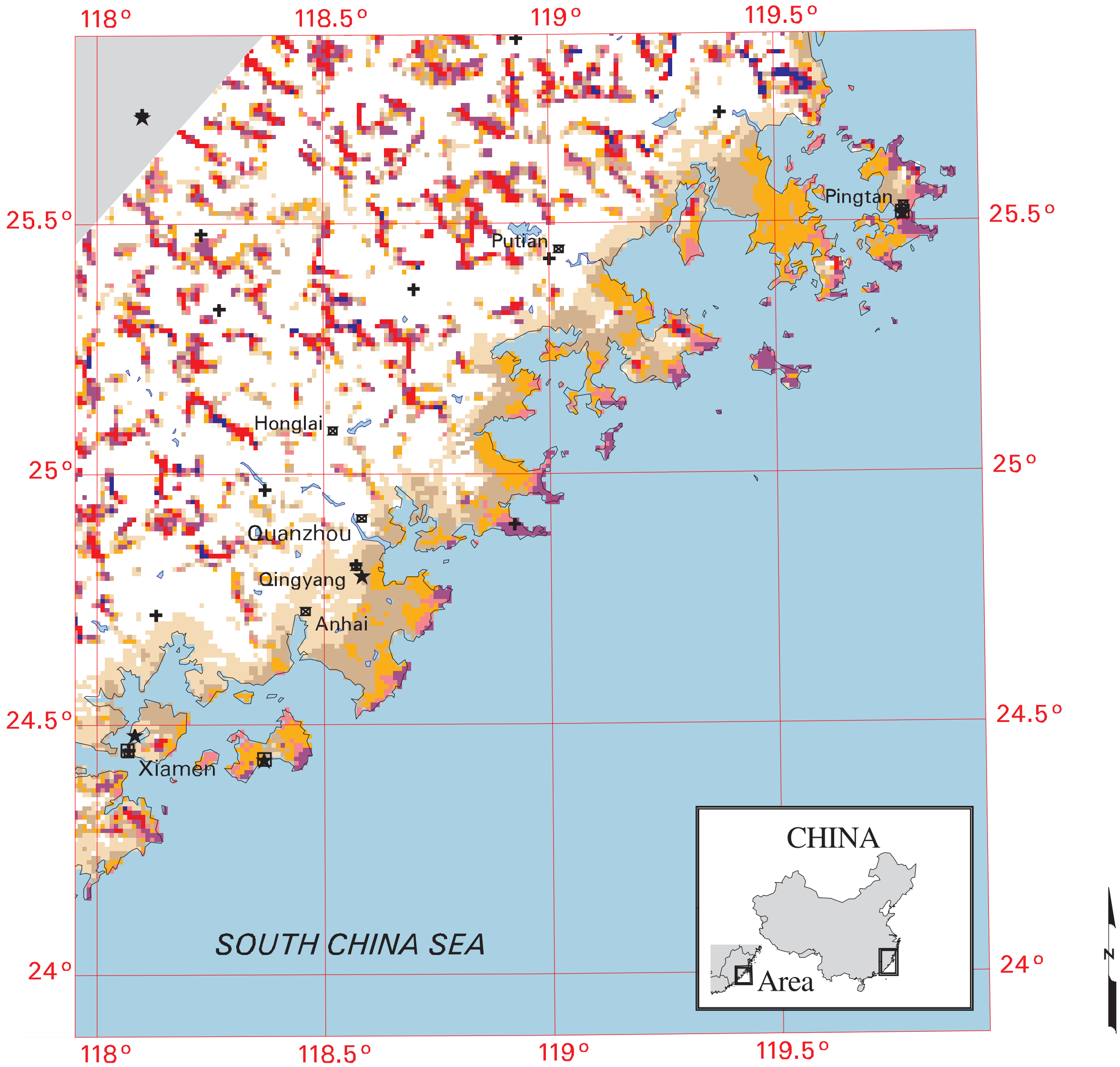
Figure 6-2

Southeast China - Central Coast of Fujian
Map of Favorable Wind Resource Areas



20 10 0 20 40 60 Kilometers

Wind Power Classification

Resource Potential	Wind Power Density at 30 m W/m^2	Wind Speed [a] at 30 m m/s
Marginal	100 - 200	4.4 - 5.6
Moderate	200 - 300	5.6 - 6.4
Good	300 - 400	6.4 - 7.0
	400 - 500	7.0 - 7.5
Excellent	500 - 700	7.5 - 8.4
	700 - 1000	8.4 - 9.6
	> 1000	> 9.6

[a] Wind speeds are based on a Weibull k value of 2.0 estimated for many coastal areas of SE China.

★ GTS Surface Meteorological Station
☐ GTS Upper-Air Meteorological Station
✚ Additional Surface Meteorological Station
⊠ City

The wind resource classification is for utility scale applications and applies to areas with low surface roughness. The Global Telecommunications System (GTS) meteorological stations are part of NREL's global database. The data for the additional wind measurement sites were provided by the China Hydropower Planning General Institute.

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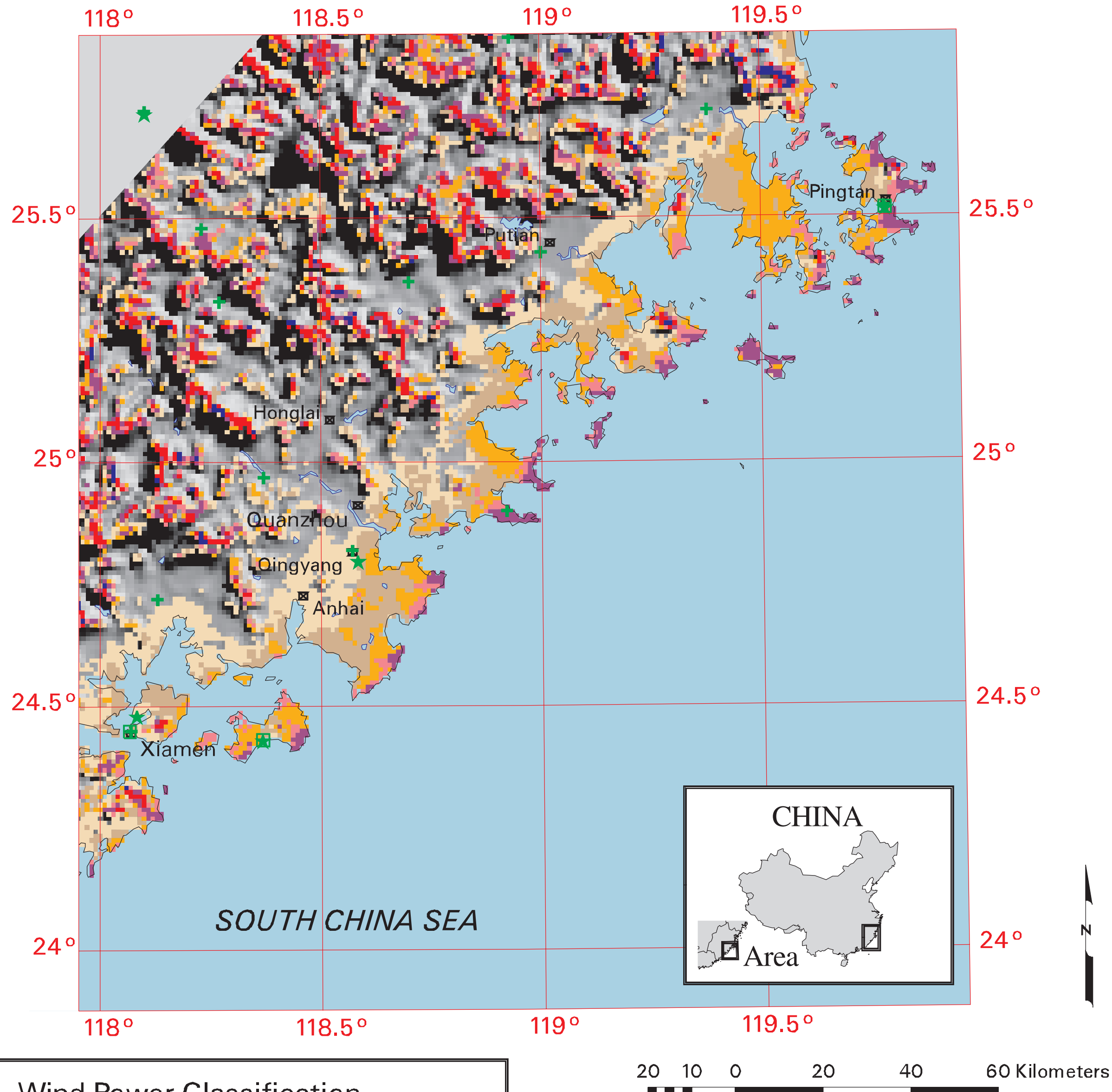
Figure 6-3

Southeast China - Central Coast of Fujian
Map of Favorable Wind Resource Areas



Wind Power Classification

Resource Potential	Wind Power Density at 30 m W/m²	Wind Speed [a] at 30 m m/s
Marginal	100 - 200	4.4 - 5.6
Moderate	200 - 300	5.6 - 6.4
Good	300 - 400	6.4 - 7.0
Excellent	400 - 500	7.0 - 7.5
	500 - 700	7.5 - 8.4
	700 - 1000	8.4 - 9.6
	> 1000	> 9.6

[a] Wind speeds are based on a Weibull k value of 2.0 estimated for many coastal areas of SE China.

★ GTS Surface Meteorological Station
□ GTS Upper-Air Meteorological Station
✚ Additional Surface Meteorological Station
⊠ City

The wind resource classification is for utility scale applications and applies to areas with low surface roughness. The Global Telecommunications System (GTS) meteorological stations are part of NREL's global database. The data for the additional wind measurement sites were provided by the China Hydropower Planning General Institute.

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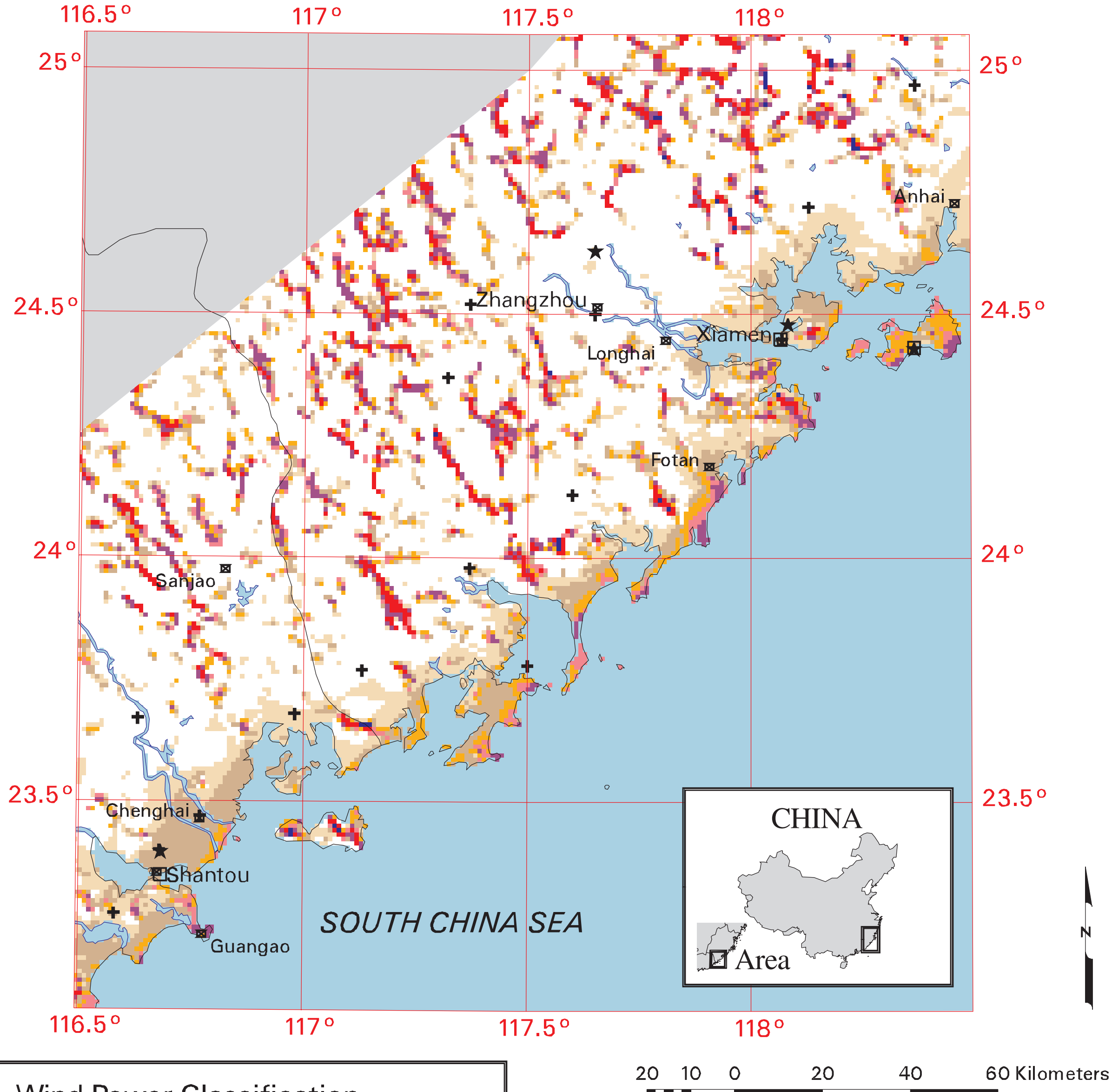
Figure 6-4

Southeast China - Southern Coast of Fujian and Eastern Coast of Guangdong - Map of Favorable Wind Resource Areas



Wind Power Classification

Resource Potential	Wind Power Density at 30 m W/m²	Wind Speed[a] at 30 m m/s
Marginal	100 - 200	4.4 - 5.6
Moderate	200 - 300	5.6 - 6.4
Good	300 - 400	6.4 - 7.0
Excellent	400 - 500	7.0 - 7.5
	500 - 700	7.5 - 8.4
	700 - 1000	8.4 - 9.6
	> 1000	> 9.6

[a] Wind speeds are based on a Weibull k value of 2.0 estimated for many coastal areas of SE China.

★ GTS Surface Meteorological Station
□ GTS Upper-Air Meteorological Station
✚ Additional Surface Meteorological Station
⊠ City

The wind resource classification is for utility scale applications and applies to areas with low surface roughness. The Global Telecommunications System (GTS) meteorological stations are part of NREL's global database. The data for the additional wind measurement sites were provided by the China Hydropower Planning General Institute.

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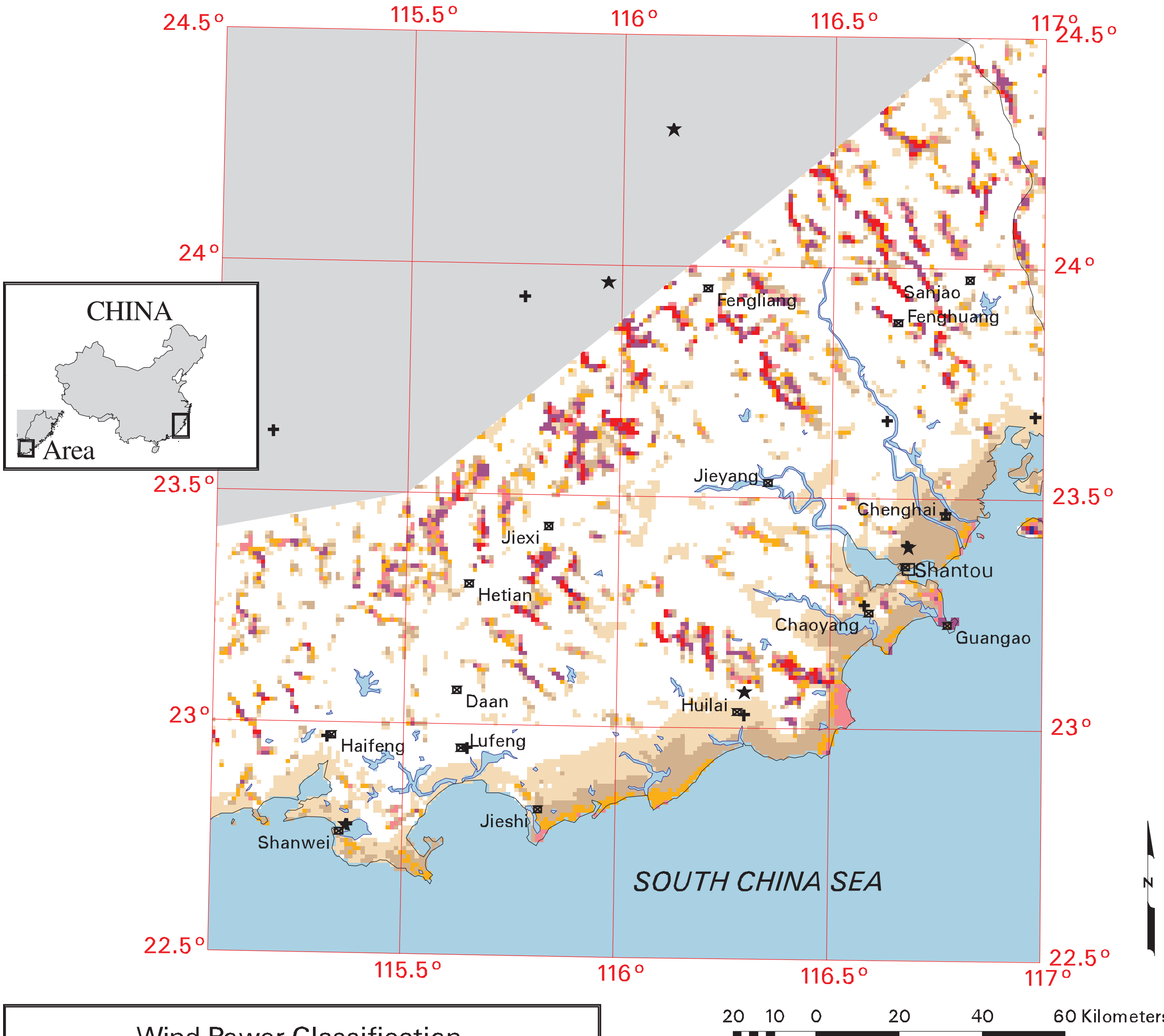
Figure 6-5

Southeast China - Eastern Coast of Guangdong
Map of Favorable Wind Resource Areas



Wind Power Classification

Resource Potential	Wind Power Density at 30 m W/m^2	Wind Speed[a] at 30 m m/s
Marginal	100 - 200	4.4 - 5.6
Moderate	200 - 300	5.6 - 6.4
Good	300 - 400	6.4 - 7.0
	400 - 500	7.0 - 7.5
Excellent	500 - 700	7.5 - 8.4
	700 - 1000	8.4 - 9.6
	> 1000	> 9.6

[a] Wind speeds are based on a Weibull k value of 2.0 estimated for many coastal areas of SE China.

★ GTS Surface Meteorological Station
☐ GTS Upper-Air Meteorological Station
✚ Additional Surface Meteorological Station
⊠ City

The wind resource classification is for utility scale applications and applies to areas with low surface roughness. The Global Telecommunications System (GTS) meteorological stations are part of NREL's global database. The data for the additional wind measurement sites were provided by the China Hydropower Planning General Institute.

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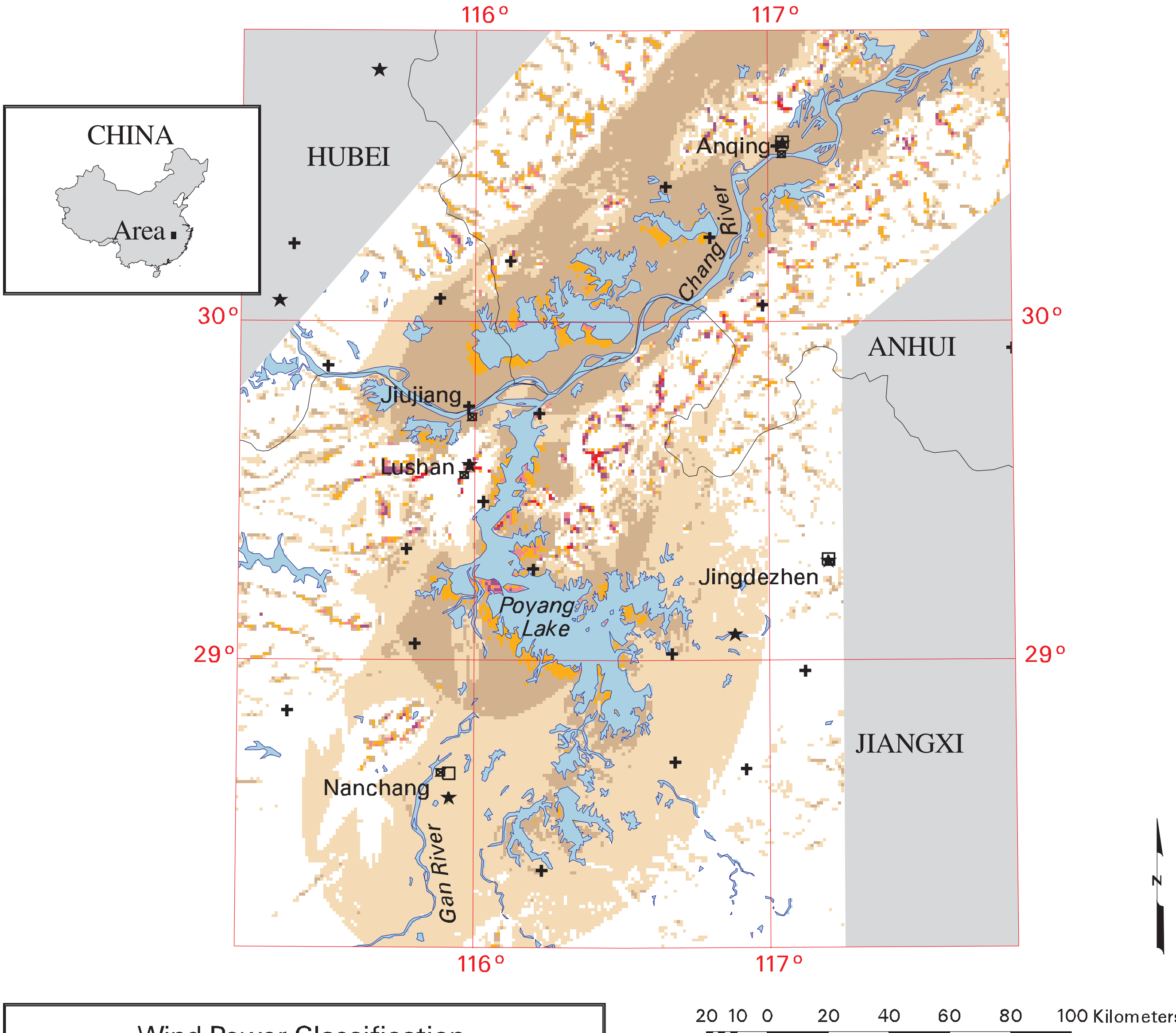
Figure 6-6

Poyang Lake Area of China
Map of Favorable Wind Resource Areas



Wind Power Classification

Resource Potential	Wind Power Density at 30 m W/m^2	Wind Speed [a] at 30 m m/s
Marginal	100 - 200	4.3 - 5.4
Moderate	200 - 300	5.4 - 6.1
Good	300 - 400	6.1 - 6.8
	400 - 500	6.8 - 7.3
Excellent	500 - 700	7.3 - 8.1
	700 - 1000	8.1 - 9.2

[a] Wind speeds are based on a Weibull k value of 1.8 estimated for the Poyang Lake area of SE China.

★ GTS Surface Meteorological Station
□ GTS Upper-Air Meteorological Station
✚ Additional Surface Meteorological Station
⊠ City

The wind resource classification is for utility scale applications and applies to areas with low surface roughness. The Global Telecommunications System (GTS) meteorological stations are part of NREL's global database. The data for the additional meteorological stations were provided by the China Hydropower Planning General Institute.

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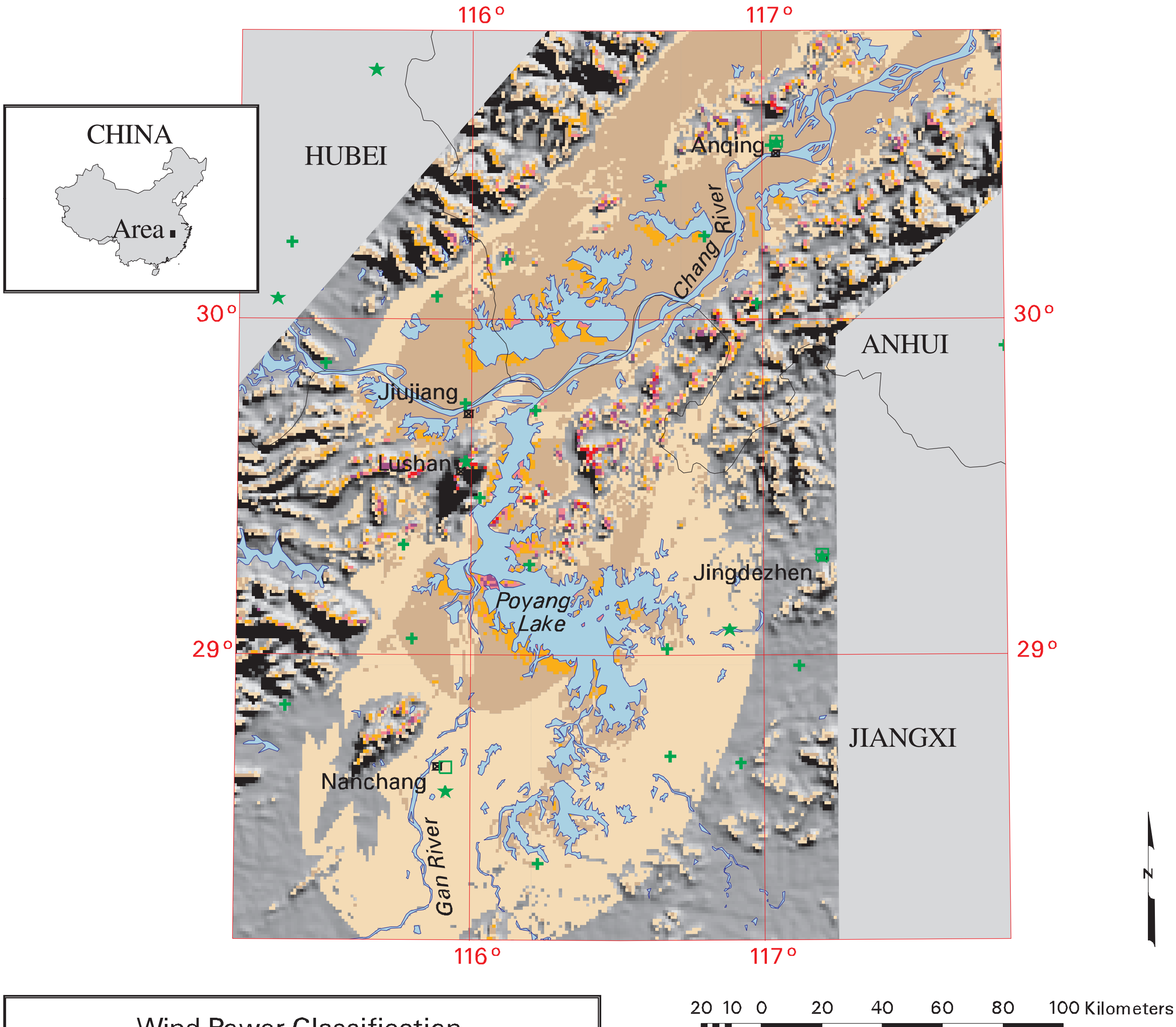
27-AUG-2002 1.4

Figure 6-7

Poyang Lake Area of China
Map of Favorable Wind Resource Areas



Wind Power Classification

Resource Potential	Wind Power Density at 30 m W/m^2	Wind Speed[a] at 30 m m/s
Marginal	100 - 200	4.3 - 5.4
Moderate	200 - 300	5.4 - 6.1
Good	300 - 400	6.1 - 6.8
Excellent	400 - 500	6.8 - 7.3
	500 - 700	7.3 - 8.1
	700 - 1000	8.1 - 9.2

[a] Wind speeds are based on a Weibull k value of 1.8 estimated for the Poyang Lake area of SE China.

- ★ GTS Surface Meteorological Station
- □ GTS Upper-Air Meteorological Station
- + Additional Surface Meteorological Station
- ⊠ City

The wind resource classification is for utility scale applications and applies to areas with low surface roughness. The Global Telecommunications System (GTS) meteorological stations are part of NREL's global database. The data for the additional meteorological stations were provided by the China Hydropower Planning General Institute.

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Figure 6-8

7.0 Wind Electric Potential

7.1 Introduction

The methods for converting the wind resource to wind electric potential were based on those in the report *Renewable Energy Technology Characterizations* (DeMeo and Galdo 1997). The assumptions used for the wind potential calculations are listed at the bottom of Table 7.1. Although the wind resource maps show the wind resources located up to 100 km inland of the coast, only land areas within 10 km of the coast and offshore islands were included in the estimates of wind energy potential. The near-coastal areas and offshore islands were thought to be more favorable for potential wind energy development than the interior areas. In the interior areas, good-to-excellent wind resource are located primarily on top of ridge crests and mountains, which are more difficult to develop than most of the near-coastal areas. Although the near-coastal areas and islands may also include many ridge crests and mountains, such as those on Nan'ao Island, there are also many coastal plains and rolling-to-hilly terrain that appear most suitable for development. However, near coastal areas appear to be more heavily populated than the inland areas, so land-use conflicts may be greater. Visits to this region show that much of the population in the near-coastal areas are generally located in the sheltered areas of low-to-marginal wind resource, rather than in the windy areas of good-to-excellent wind resource. The windy areas of potential wind farm development that were visited were only sparsely populated, and land-use conflicts appeared minimal. Some areas within the shelter belts and tree cover would require greater hub-heights (e.g., 50 m) to avoid possible wind shear and turbulence problems.

Each color-coded square kilometer on the map has an assigned annual wind power density at the 30-m height, expressed in units of W/m^2. NREL developed an equation to compute the total net annual energy delivery for grid cells with an annual wind power density of 200 W/m^2 and greater. If the wind power density of a grid cell was less than 200 W/m^2, then the net potential was set equal to zero. Another scenario presented in this section included only those grid cells with an annual average power density of 300 W/m^2 and greater.

The wind resource classifications in Table 7.1 are the same as those shown on the wind resource maps for southeast China. The installed capacity and total power values in the table represent net wind electric potential not reduced by factors such as land-use exclusions. The net energy already has been reduced about 15% to 20% by expected losses such as wind turbine maintenance and wake effects, among other factors.

7.2 Wind Electric Potential Estimates

More than 4,000 km^2 of windy land areas have been estimated to have good-to-excellent wind resource potential. The proportion of windy land and potential wind capacity for each wind power category is listed in Table 7.1. This amount of windy land, using conservative assumptions that result in about 7 MW of capacity per km^2, could support more than 28,000 MW of installed capacity and potentially deliver more than 73 billion kWh per year. Additional studies are required to more accurately assess the wind electric potential, considering factors such as the existing grid and accessibility.

If additional areas with moderate wind resource potential are considered, the estimated total windy land area (as shown in Table 7.1) increases to more than 7,000 km^2. This amount of windy land could support almost 52,000 MW of installed capacity and potentially deliver almost 114 billion kWh per year.

Table 7.1 Southeast China – Wind Electric Potential

Good-to-Excellent Wind Resource at 30 m

Wind Class	Wind Power at 30 m W/m^2	Wind Speed at 30 m m/s*	Total Area km^2	Percent Windy Land	Total Capacity Installed MW	Total Power GWh/yr
3	300-400	6.4-7.0	1,908	10.9	13,200	29,600
4	400-500	7.0-7.5	941	5.4	6,500	17,200
5	500-700	7.5-8.4	864	4.9	6,000	18,400
6	700-1000	8.4-9.6	313	1.8	2,200	7,400
7	>1000	>9.6	45	0.3	300	900
Total			4,071	23.3	28,200	73,500

Moderate-to-Excellent Wind Resource at 30 m (Utility Scale)

Wind Class	Wind Power at 30 m W/m^2	Wind Speed at 30 m m/s*	Total Area km^2	Percent Windy Land	Total Capacity Installed MW	Total Power GWh/yr
2	200-300	5.6-6.4	3,376	19.3	23,400	40,400
3	300-400	6.4-7.0	1,908	10.9	13,200	29,600
4	400-500	7.0-7.5	941	5.4	6,500	17,200
5	500-700	7.5-8.4	864	4.9	6,000	18,400
6	700-1,000	8.4-9.6	313	1.8	2,200	7,400
7	>1,000	>9.6	45	0.3	300	900
Total			7,447	42.6	51,600	113,900

* **Wind speeds are based on a Weibull k value of 2.0**

Assumptions
Turbine Size – 500 kW
Hub Height – 40 m
Rotor Diameter – 38 m
Turbine Spacing – 10D by 5D
Capacity/km^2 – 6.9 MW

Acknowledgments

Special thanks go to Debbie Lew of NREL, whose tireless efforts and support made publication of this wind atlas possible.

We are grateful to Shi Pengfei and Yi Yuechun of CHPGI for their assistance in identifying the regions for the wind assessment and mapping project, obtaining wind data from additional meteorological stations in southeast China, and identifying and establishing wind monitoring sites for the EPA/AWEA-sponsored measurement program. We appreciate the assistance of Peter Tu of NREL in collaborating with Chinese organizations to facilitate project activities. We acknowledge Bruce Bailey and Mike Markus of AWS Scientific, Inc., for their assistance in the review and documentation of the methods and initial preparation of the original report. We thank Kevin Rackstraw and Scott Vaupen of AWEA for their support and management of NREL's wind mapping activities on this project and for their efforts leading to the wind measurement program conducted by CHPGI.

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Schwartz, M; Elliott, D. (2001). Remapping of the Wind Energy Resource in the Midwestern United States: Abstract Preprint. 9 pp.; NICH Report No. AB-500-31083.

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Appendix A:

Nan’ao Island Wind Resource Assessment

Nan'ao Island Wind Resource Assessment

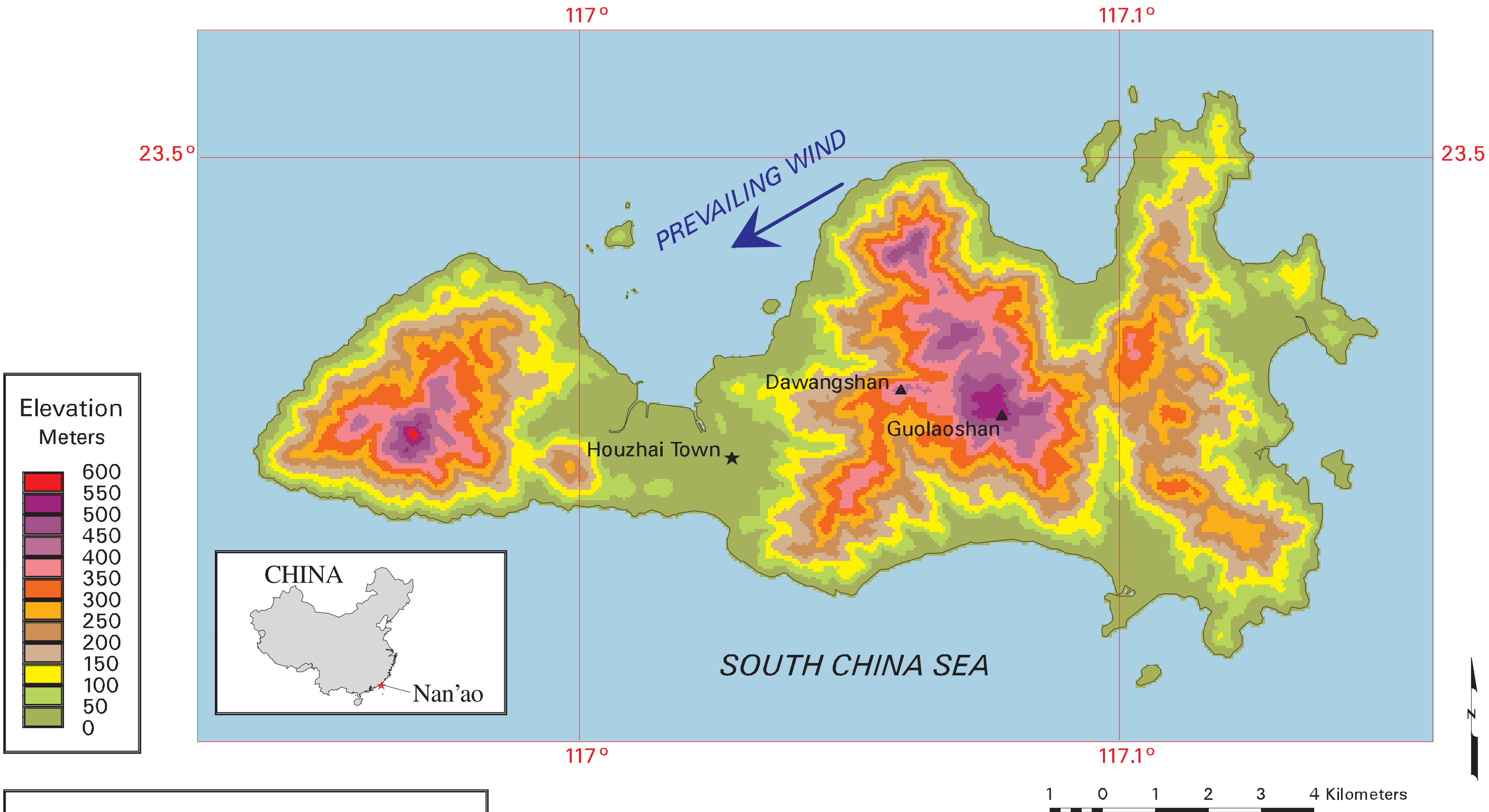
Nan'ao Island is a small island (approximately 20 km E-W by 5-10 km N-S) in the southeastern coastal region of China. In conjunction with a World Bank feasibility study in 1996 to examine the wind resource potential in specific areas of China, NREL developed a computerized wind resource map of Nan'ao Island. China wanted the World Bank to include Nan'ao Island as a candidate for a 50-MW wind energy development project, but it did not have the capability to develop a comprehensive wind resource map and produce reliable estimates of the wind electric potential that could be developed on the island.

Four computer-based maps were produced by the wind resource assessment group at NREL for the Nan'ao Island Wind Farm Case Study. These maps include an elevation map of Nan'ao, a hill-shaded relief map of the island, a map of the level of wind resource at the most favorable wind resource areas on Nan'ao, and a map of the favorable wind resource areas superimposed on the hill-shaded relief map. Together these maps provide a comprehensive guide to siting viable wind farms on the island.

There were two sources of the topographic and meteorological data used in the development of the computer-based maps. Chinese agencies, through the World Bank, provided topographic and meteorological data from Nan'ao Island that were the foundation of the mapping project. The topographic information provided by the Chinese was a detailed (10-m contours) paper topographic map of Nan'ao and the surrounding small islands. The meteorological data received from the Chinese via the World Bank included a one-year (1988) period of wind data and wind direction from three surface sites on the island: Houzhai Town, Dawangshan, and Guolaoshan and a 20-year summary of monthly mean wind speeds from one of those sites (Houzhai Town). The locations of the three sites are located on each map. Additional meteorological data for the Nan'ao region was gathered from the global database already established at NREL. This database not only included surface data but also upper-air data from weather balloons and historical ship wind speed data. The ship and weather balloon data from the Nan'ao region were crucial in determining the locations of the most favorable wind resource areas on the island and the level of wind resource at these areas.

An extensive wind measurement program is underway in Nan'ao, and wind power development projects are proceeding.

Nan'ao Island, China - Elevation Map



Legend

★ Meteorological Station with Wind Data
▲ Other Site with Wind Data

The prevailing wind direction is 60 degrees.

The elevation map was derived from a digital elevation model that was interpolated from topographic contour lines. The wind data sites are from the Nan'ao Wind Farm Case Study Analysis (draft).

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Nan'ao Island, China - Hill Shaded Relief Map

Legend

★ Meteorological Station with Wind Data
▲ Other Sites with Wind Data

The prevailing wind direction is 60 degrees.

The shaded relief map was interpolated from topographic contour lines. The sites for wind data are from the Nan'ao Wind Farm Case Study Analysis (draft).

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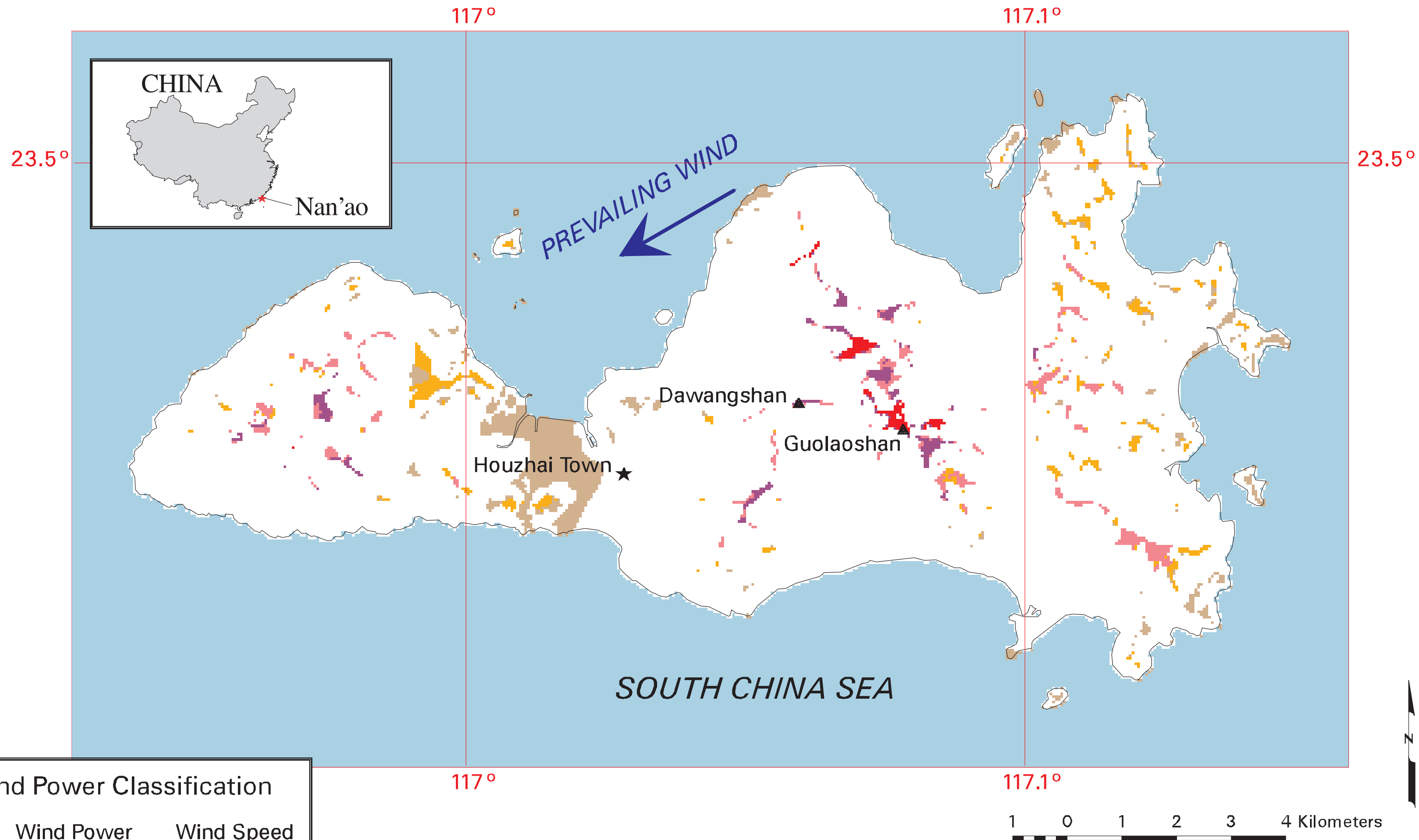
Nan'ao Island, China - Favorable Wind Resource Areas



Wind Power Classification

Wind Power W/m2	Wind Speed m/s
300 - 400	5.8 - 6.8
400 - 500	6.8 - 7.5
500 - 600	7.5 - 8.1
600 - 700	8.1 - 8.7
> 700	> 8.7

★ Meteorological Station
▲ Other Site with Wind Data

The wind resource analysis and classification were developed by the NREL Wind Resource Assessment Program. The wind data sites are from the Nan'ao Wind Farm Case Study Analysis (draft). The prevailing wind direction is 60 degrees.

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13-SEP-2001 1.2

Nan'ao Island, China - Favorable Wind Resource Areas

Wind Power Classification

Wind Power W/m^2	Wind Speed m/s
300 - 400	5.8 - 6.8
400 - 500	6.8 - 7.5
500 - 600	7.5 - 8.1
600 - 700	8.1 - 8.7
> 700	> 8.7

★ Meteorological Station
▲ Other Site with Wind Data

The wind resource analysis and classification were developed by the NREL Wind Resource Assessment Program. The wind data sites are from the Nan'ao Wind Farm Case Study Analysis (draft). The prevailing wind direction is 60 degrees.

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13-SEP-2001 1.6

Appendix B:

China Hydropower Wind Measurement Sites Data Summaries

Aozi
Changjiangao
Changchun
Laoyemiao
Haiwanshi
Zhanjiang
Xiaoqingdao
Dongwangsha

Southeast China Wind Measurement Program Summary

The China Hydropower Planning General Institute (CHPGI) of the State Power Corporation (SPC) of China conducted a measurement program in southeast China, using instrumentation supplied by the American Wind Energy Association (AWEA) with funding support from the U.S. Environmental Protection Agency (EPA). The program included three sites in Fujian province, two in Jiangxi, two in Guangdong, one in Shandong and one in the Shanghai area. The equipment at one of the Jiangxi sites was destroyed by floodwaters and no data were ever received. The sites in Fujian, Jiangxi, and Guangdong are described as being located at wind farms.

The sites in Fujian and Guangdong used NRG data loggers, while the sites in Jiangxi and Shanghai used SecondWind loggers. The station at Xiaoqingdao used an NRG logger, but the exact site location is not known. The vane at Laoyemiao was damaged, so there are no wind direction data.

Each site recorded data at one, two, or three heights, ranging from 10 to 50 meters above ground level. There were a total of 20 measurement heights for the eight sites where data were collected.

Data were received from the CHPGI in the form of text files. We do not know how these text files were produced. No raw or processed files from either the NRG or SecondWind software were received, making it difficult to understand the cause of missing or corrupted data.

Location information was provided in most of the text files and was given to a precision of one minute. The accuracy of some of these measurements is suspect. (Zhangjiang and Shanghai have locations that are in the ocean.) NREL estimated the locations for Laoyemiao and Changchun from detailed topographic maps supplied by CHPGI because the earlier coordinates provided by CHPGI were obviously in error. No site descriptions were available, so the effects of local vegetation and topography are unknown.

Table B.1 shows a summary of the sites with locations, measurement heights, and wind data statistics. Graphs of additional wind characteristics for these sites are presented in this section, following Table B.1. These wind characteristics include:

- Speed and power by month
- Number of observations by month
- Speed and power by hour
- Frequency and speed by direction
- Frequency of speed and percent of power by speed.

Files containing the hourly observations from these stations can be found on the CD that accompanies this report.

Table B.1 China Hydropower Wind Measurement Site Data Summaries

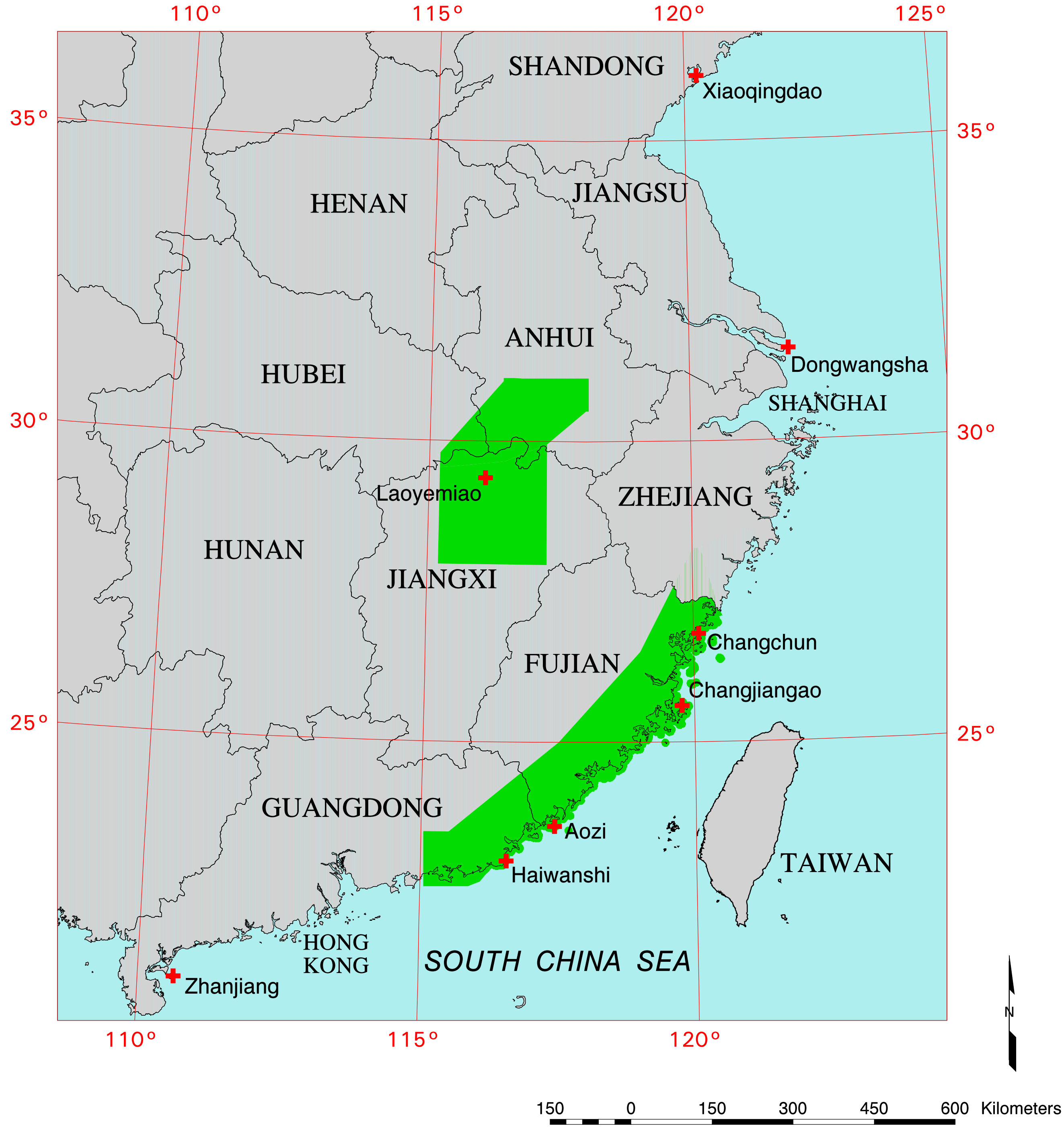
Province	Name	ID	Ht	WS	WPD	DR	From	To	Lat	Lon	Elev
Fujian	Aozi	20	40	6.6	355	19454	1998-09	2000-12	23 36	117 25	*55*
		21	25	6.1	294	17634	1998-09	2000-12	23 36	117 25	*55*
		22	10	5.5	233	18477	1998-09	2000-12	23 36	117 25	*55*
Fujian	Changjiangao	70	50	8.0	557	23762	1998-03	2000-12	25 36	119 46	*33*
		71	30	6.4	278	23762	1998-03	2000-12	25 36	119 46	*33*
		72	20	5.2	160	23762	1998-03	2000-12	25 36	119 46	*33*
Fujian	Changchun	80	40	5.2	203	18142	1998-11	2000-11	26 48	120 05	*12*
		81	25	5.1	192	18144	1998-11	2000-11	26 48	120 05	*12*
		82	10	4.9	180	18144	1998-11	2000-11	26 48	120 05	*12*
Jiangxi	Laoyemiao	60	50	6.0	375	3840	1999-07	1999-12	29 23	116 04	120
		61	40	6.0	382	3811	1999-07	1999-12	29 23	116 04	120
		62	10	5.0	219	3822	1999-07	1999-12	29 23	116 04	120
Guangdong	Haiwanshi	40	25	7.0	367	4844	1998-08	1999-03	23 01	116 33	15
		41	10	5.5	193	4844	1998-08	1999-03	23 01	116 33	15
Guangdong	Zhanjiang	90	20	5.6	199	14423	1998-07	2000-03	20 55	110 38	15
		91	10	5.4	183	14421	1998-07	2000-03	20 55	110 38	15
Shandong	Xiaoqingdao	130	10	5.0	189	4835	1997-03	1998-01	*36 04*	*120 15*	*20*
Shanghai	Dongwangsha	30	50	6.3	265	8821	1998-05	2000-10	31 31	121 56	8
		31	40	6.2	232	9221	1998-05	2000-05	31 31	121 56	8
		32	10	4.6	133	12022	1998-05	2000-10	31 31	121 56	8

ID is a unique station and measurement height identifier assigned at NREL. Anemometer heights (**Ht**) are given in meters above ground, wind speeds (**WS**) are in meters per second, and wind power densities (**WPD**) are in Watts/meter^2. Data recovery (**DR**) is given as the total number of hours of wind data collected. Latitude (**Lat**) is in degrees and minutes north. Longitude (**Lon**) is in degrees and minutes east. Elevations (**Elev**) are given in meters above sea level.

WS and **WPD** are averages for the total number of hours of data collected. They do not represent annual averages.

Values in *italics* are estimated.

Southeast China
NREL/CHPGI Wind Measurement Sites



The data for the wind measurement sites were provided by the China Hydropower Planning General Institute (CHPGI).

Legend

- NREL/CHPGI Wind Measurement Site
- Wind Resource Mapping Area

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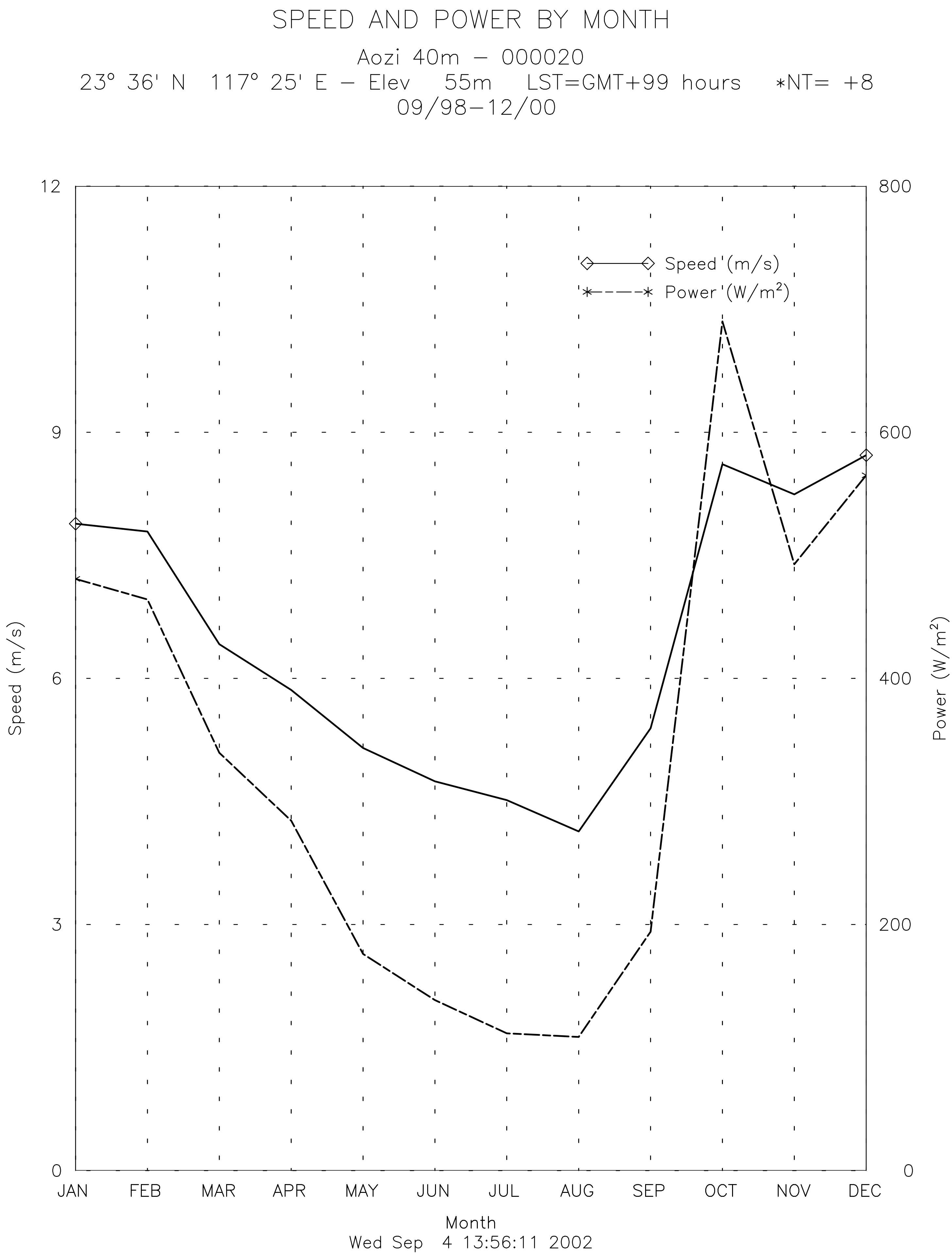
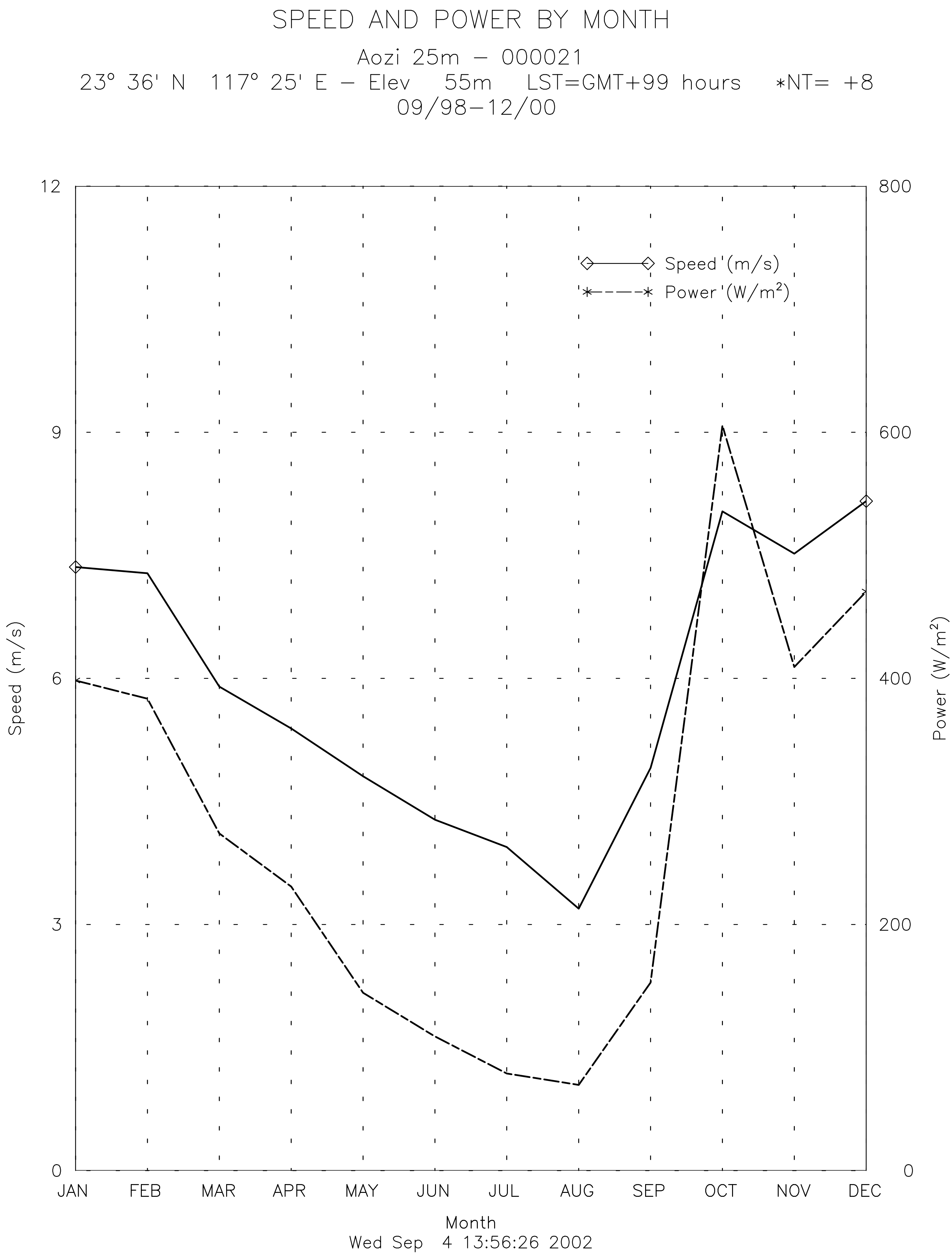
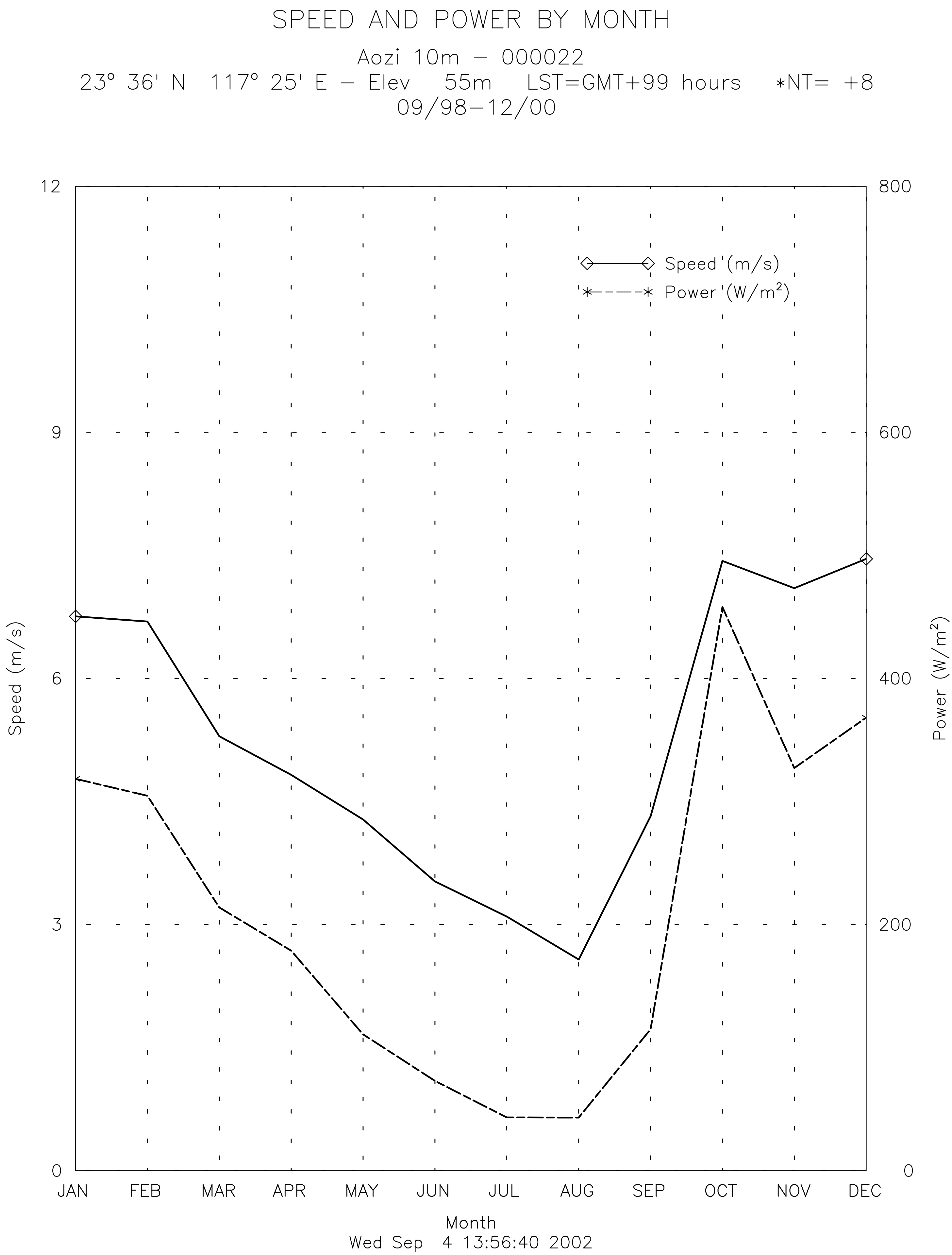
21-AUG-2002 1.2.1

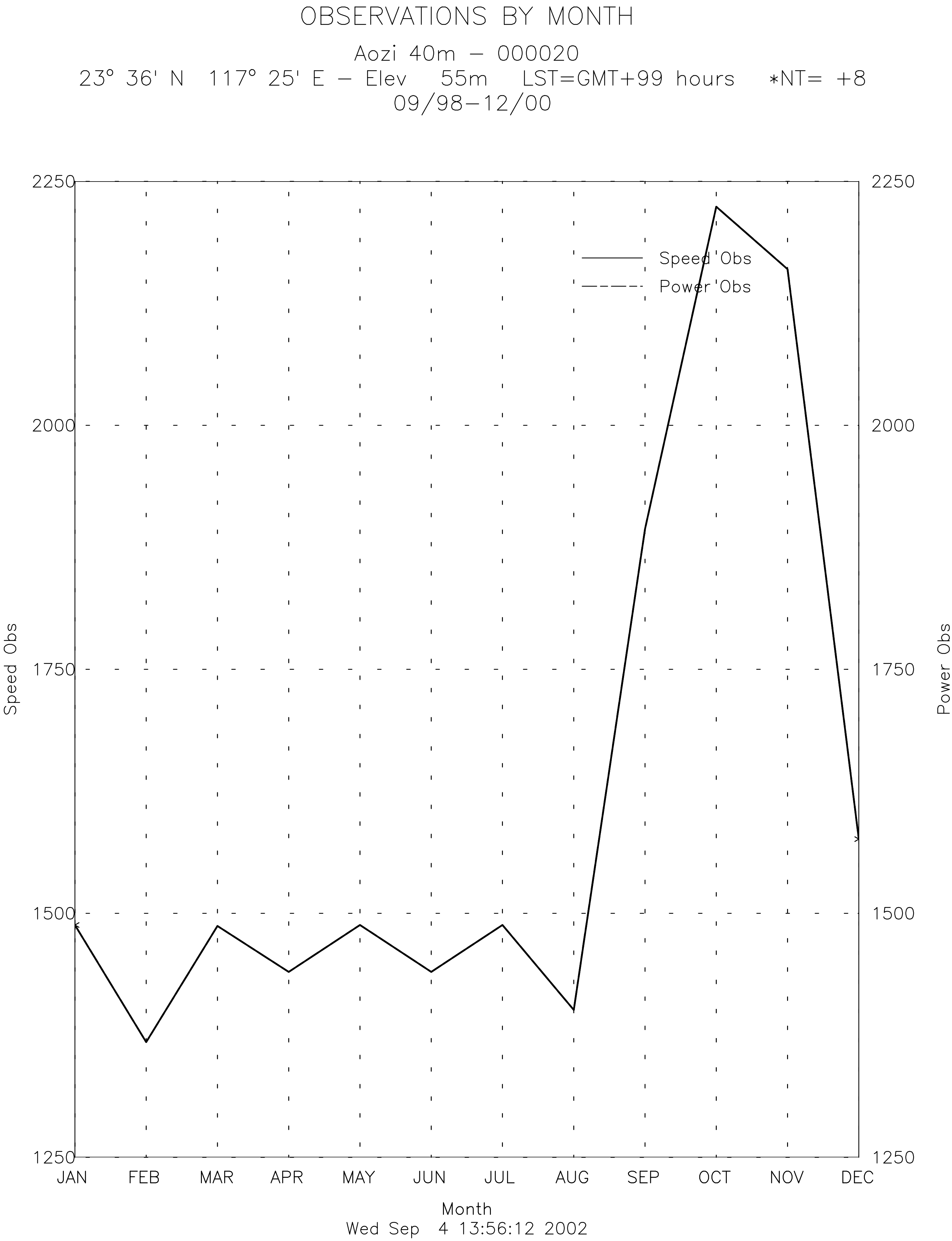


SPEED AND POWER BY MONTH
Aozi 40m - 000020
23° 36' N 117° 25' E - Elev 55m LST=GMT+99 hours *NT= +8
09/98-12/00
Speed (m/s)
Power (W/m²)
Speed (m/s)
Power (W/m²)
12
9
6
3
0
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:56:11 2002


SPEED AND POWER BY MONTH
Aozi 25m - 000021
23° 36' N 117° 25' E - Elev 55m LST=GMT+99 hours *NT= +8
09/98-12/00
Speed (m/s)
Power (W/m²)
Speed (m/s)
Power (W/m²)
12
9
6
3
0
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:56:26 2002



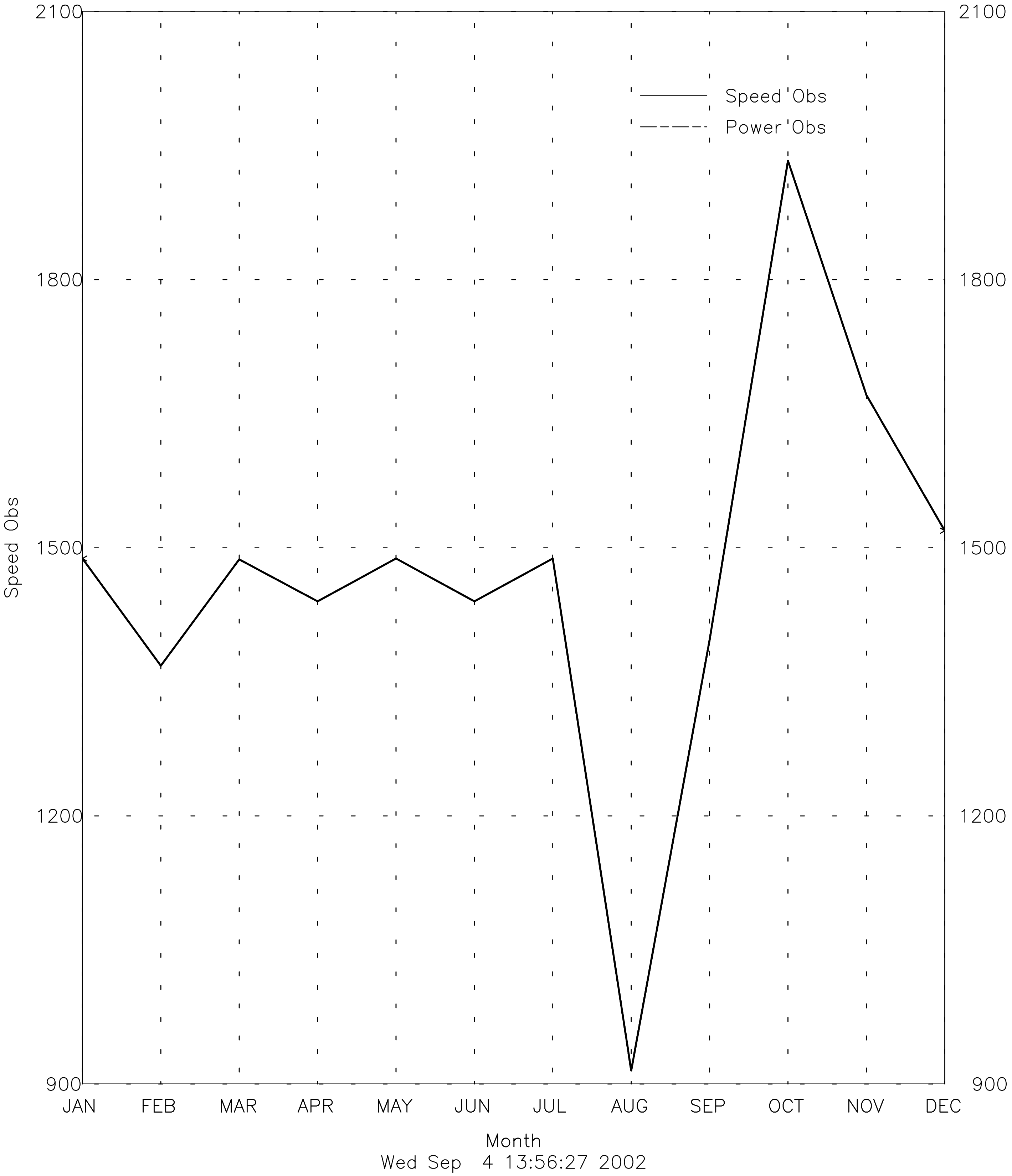
SPEED AND POWER BY MONTH
Aozi 10m - 000022
23° 36' N 117° 25' E - Elev 55m LST=GMT+99 hours *NT= +8
09/98-12/00
Speed (m/s)
Power (W/m²)
Month
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
0 3 6 9 12
0 200 400 600 800
Wed Sep 4 13:56:40 2002



OBSERVATIONS BY MONTH
Aozi 40m - 000020
23° 36' N 117° 25' E - Elev 55m LST=GMT+99 hours *NT= +8
09/98-12/00
Speed Obs
Power Obs
2250
2000
1750
1500
1250
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:56:12 2002

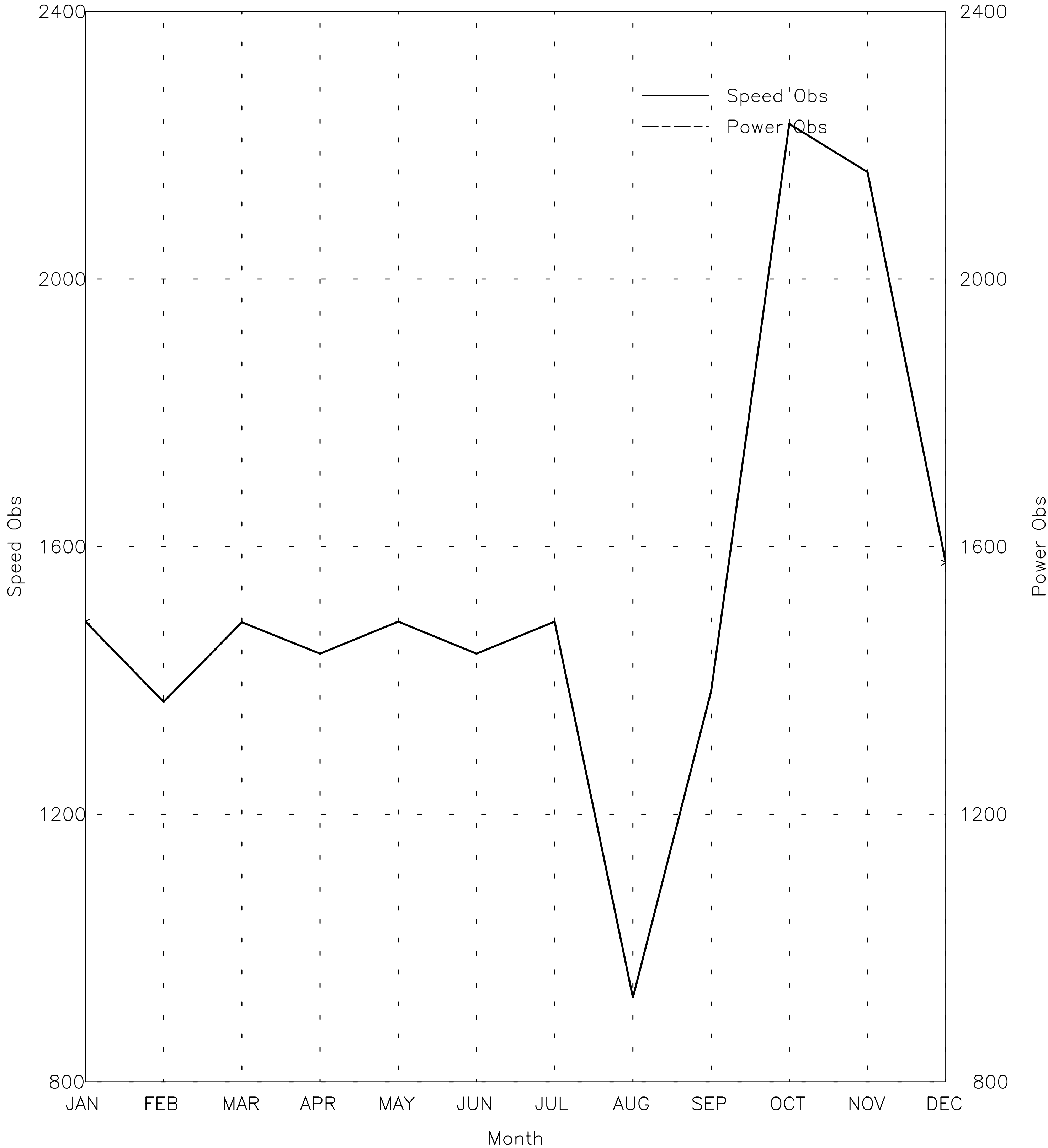
OBSERVATIONS BY MONTH

Aozi 25m - 000021
23° 36' N 117° 25' E - Elev 55m LST=GMT+99 hours *NT= +8
09/98-12/00



OBSERVATIONS BY MONTH

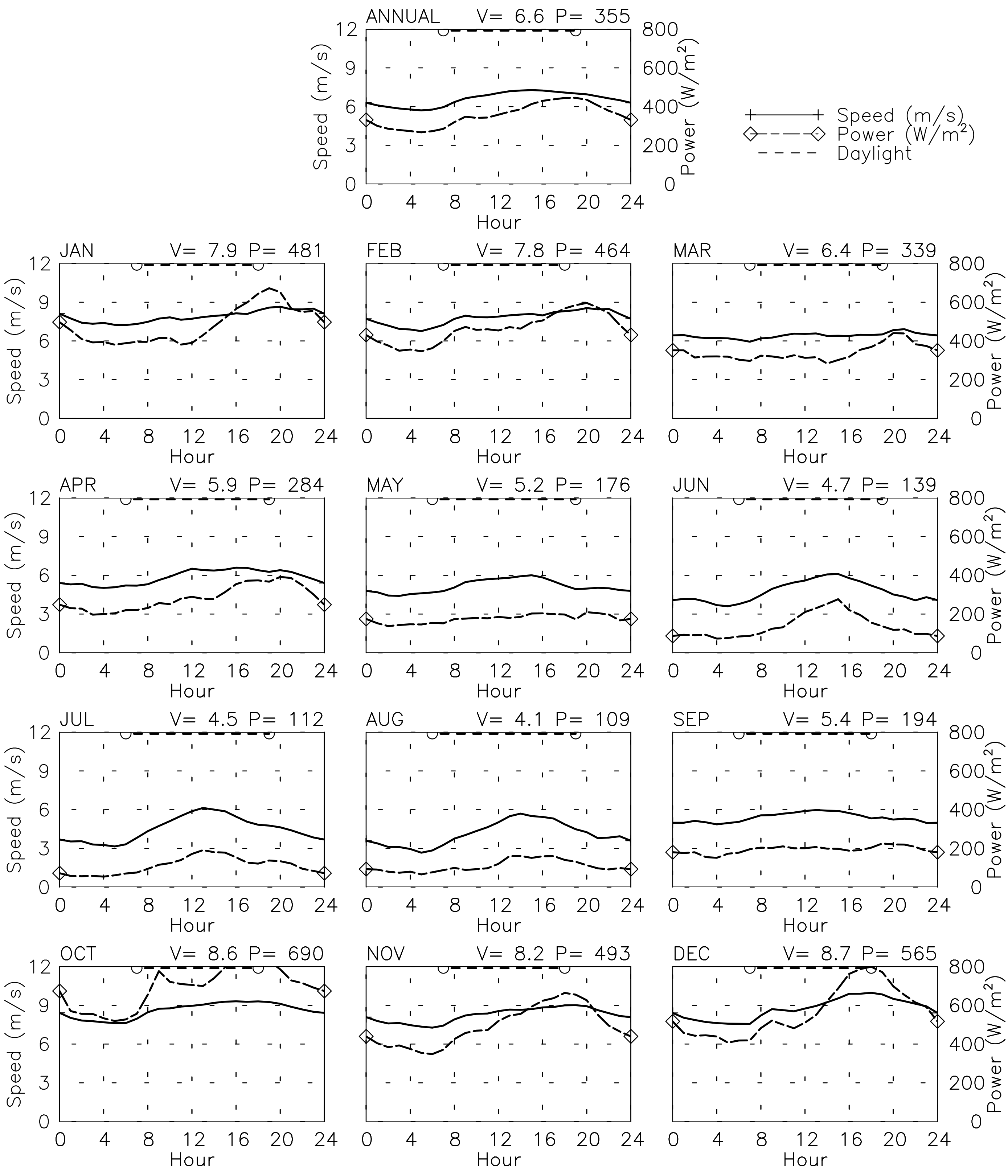
Aozi 10m - 000022
23° 36' N 117° 25' E - Elev 55m LST=GMT+99 hours *NT= +8
09/98-12/00



Wed Sep 4 13:56:42 2002

SPEED AND POWER BY HOUR

Aozi 40m - 000020
23° 36' N 117° 25' E - Elev 55m LST=GMT+99 hours *NT= +8
09/98-12/00



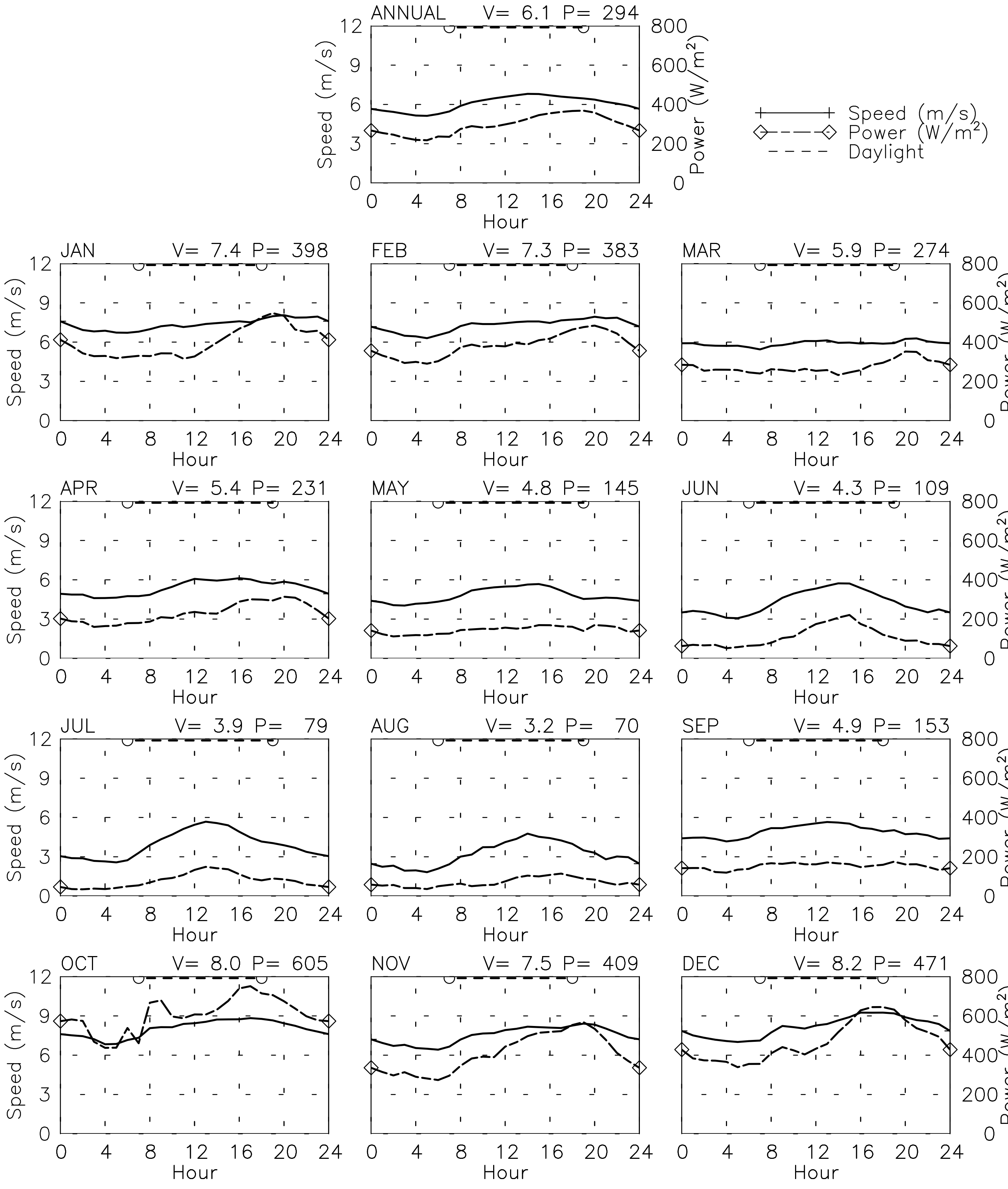
Wed Sep 4 13:56:14 2002

SPEED AND POWER BY HOUR

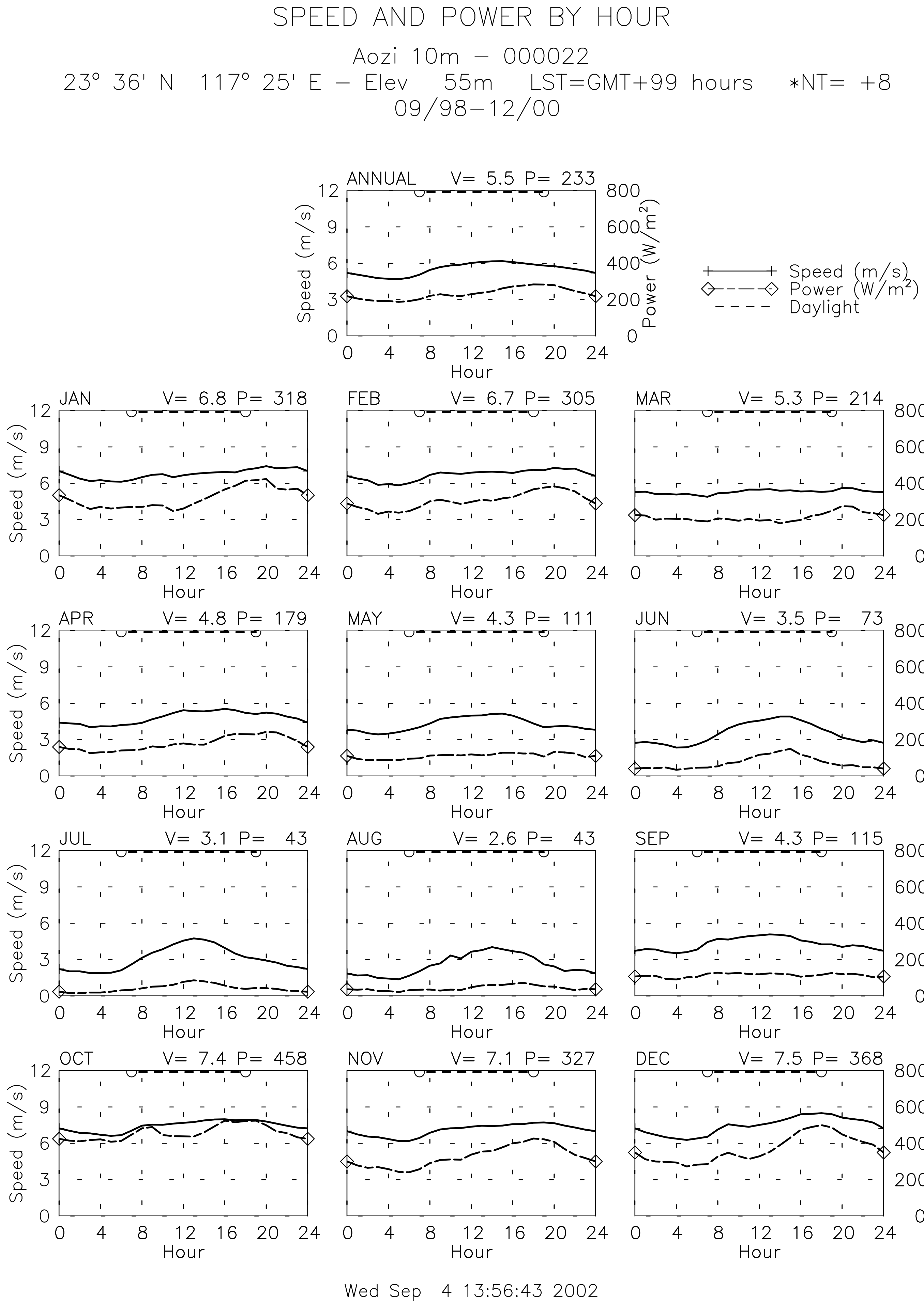
Aozi 25m – 000021

23° 36' N 117° 25' E – Elev 55m LST=GMT+99 hours *NT= +8

09/98–12/00



Wed Sep 4 13:56:28 2002

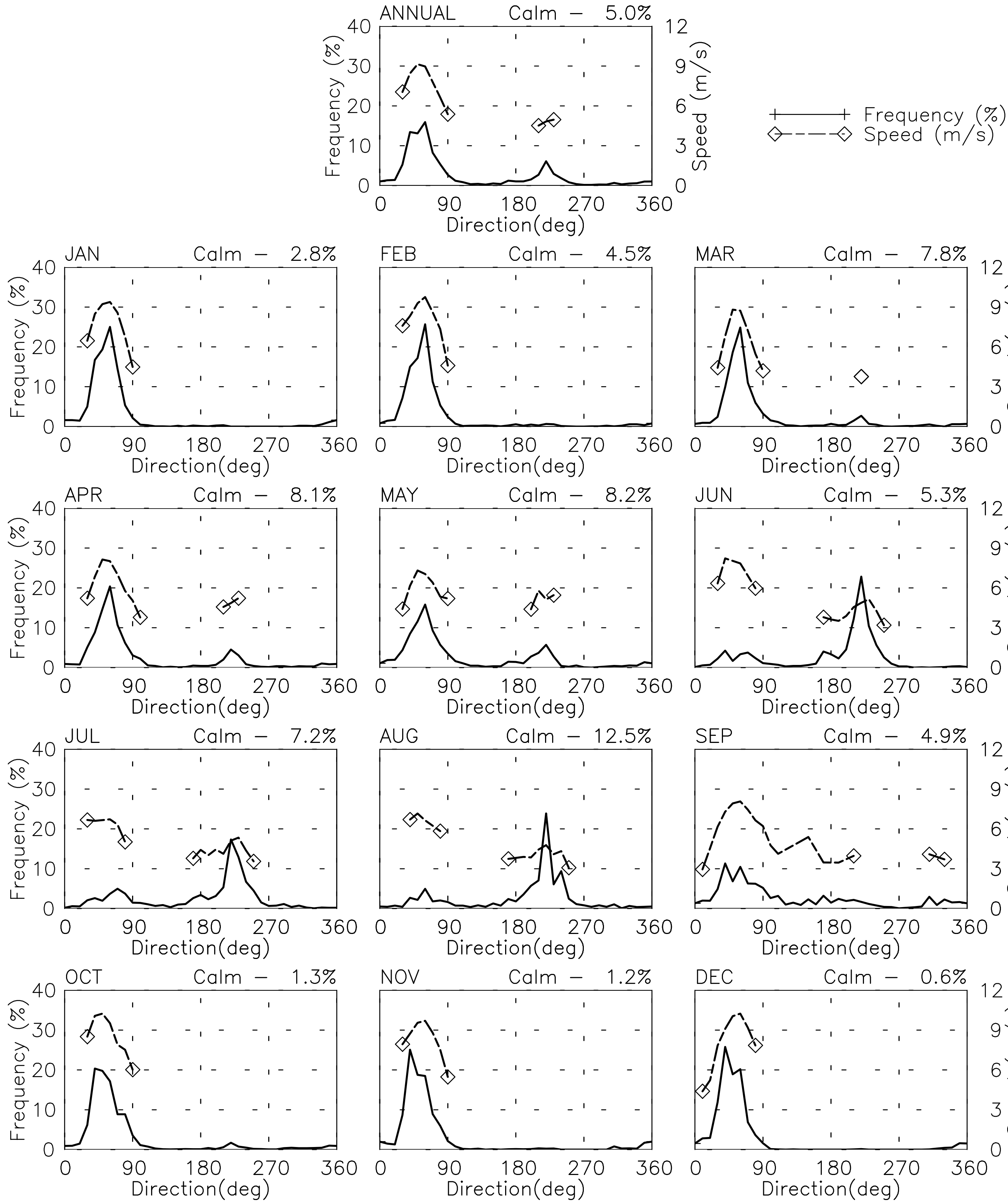

SPEED AND POWER BY HOUR
Aozi 10m - 000022
23° 36' N 117° 25' E - Elev 55m LST=GMT+99 hours *NT= +8
09/98-12/00
ANNUAL V= 5.5 P= 233
Speed (m/s)
Power (W/m²)
Daylight
JAN V= 6.8 P= 318
FEB V= 6.7 P= 305
MAR V= 5.3 P= 214
APR V= 4.8 P= 179
MAY V= 4.3 P= 111
JUN V= 3.5 P= 73
JUL V= 3.1 P= 43
AUG V= 2.6 P= 43
SEP V= 4.3 P= 115
OCT V= 7.4 P= 458
NOV V= 7.1 P= 327
DEC V= 7.5 P= 368
Hour
Wed Sep 4 13:56:43 2002

FREQUENCY AND SPEED BY DIRECTION

Aozi 40m - 000020

23° 36' N 117° 25' E - Elev 55m LST=GMT+99 hours *NT= +8

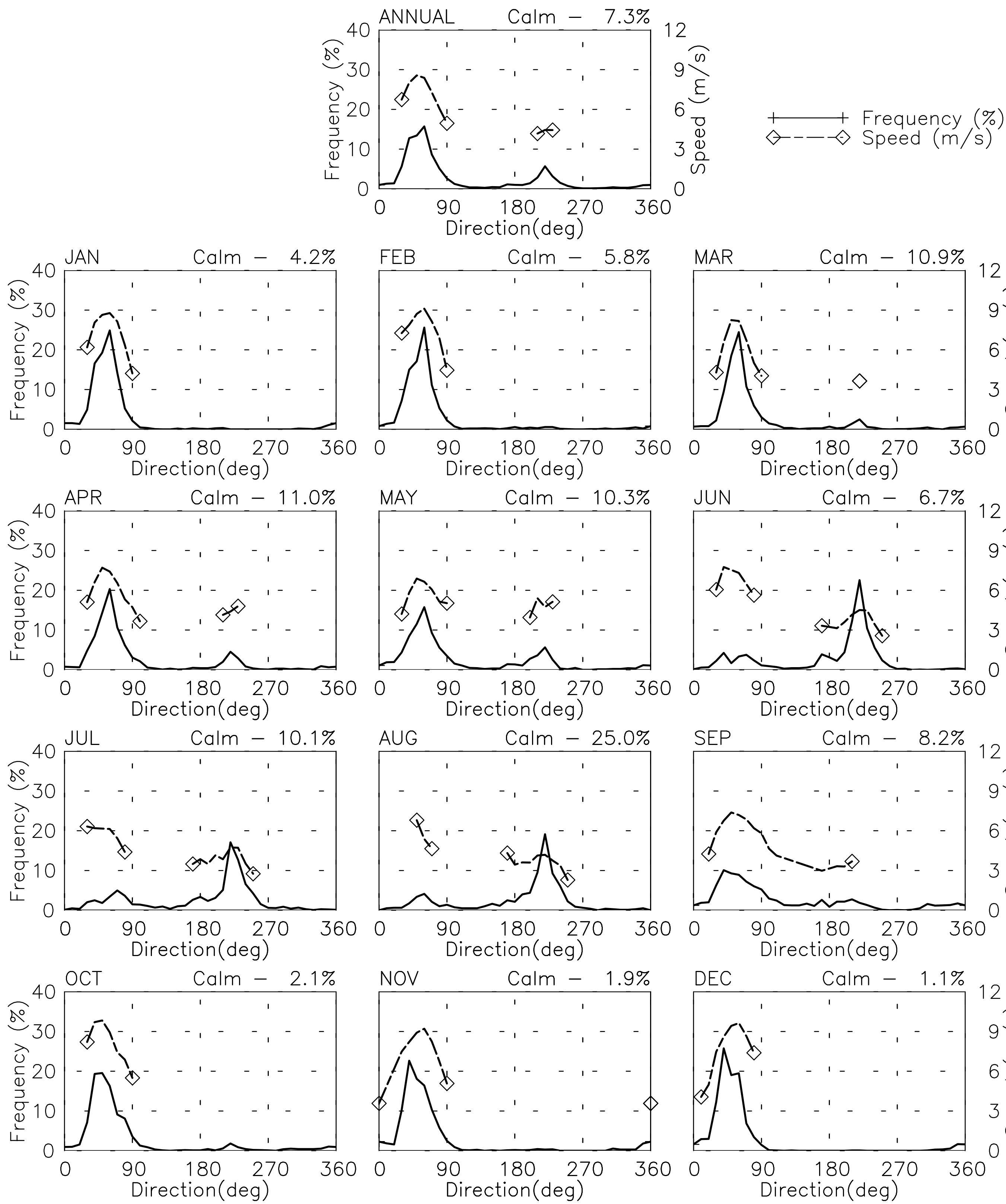
09/98-12/00



Wed Sep 4 13:56:17 2002

FREQUENCY AND SPEED BY DIRECTION

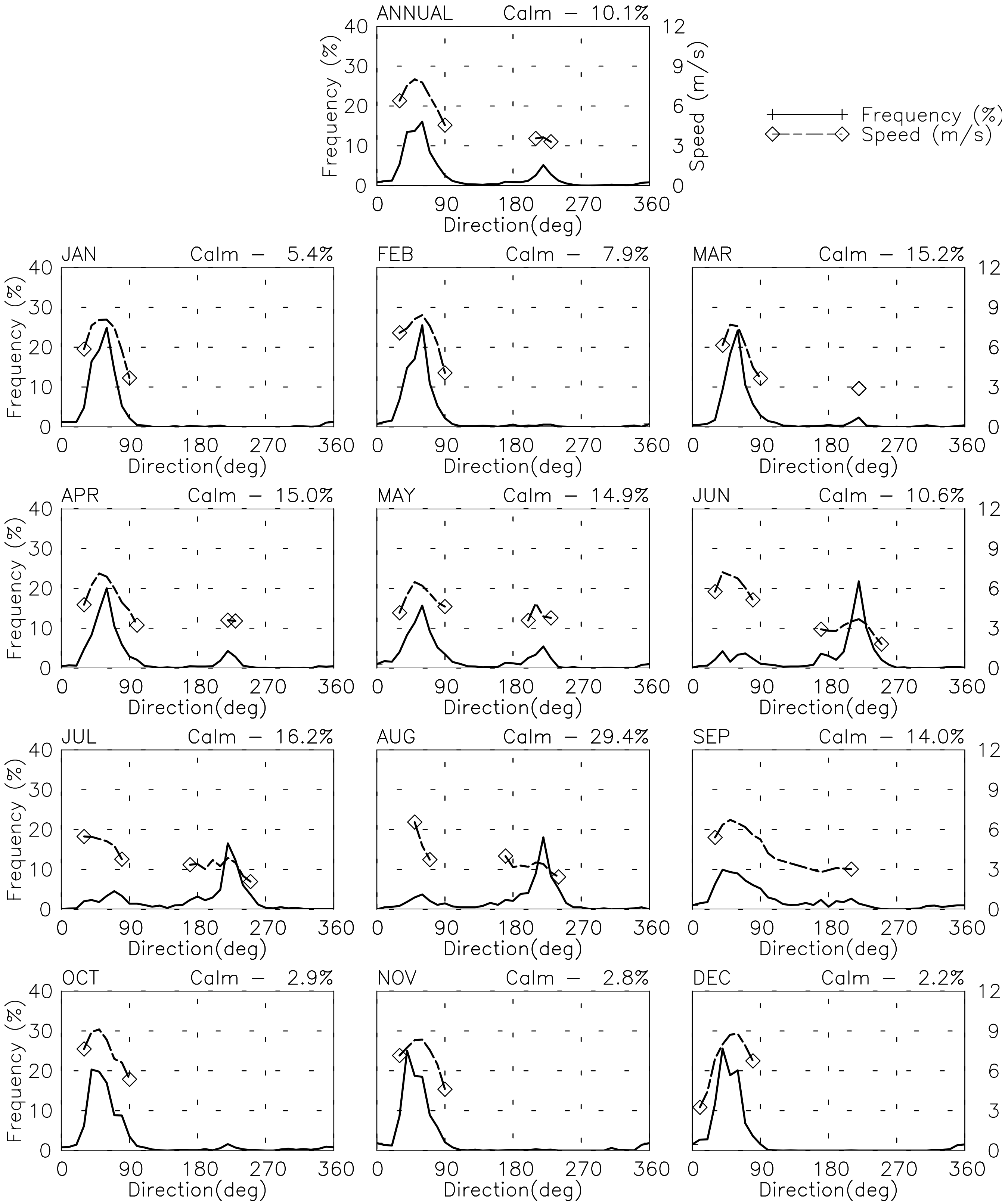
Aozi 25m - 000021
23° 36' N 117° 25' E - Elev 55m LST=GMT+99 hours *NT= +8
09/98-12/00



Wed Sep 4 13:56:31 2002

FREQUENCY AND SPEED BY DIRECTION

Aozi 10m – 000022
23° 36' N 117° 25' E – Elev 55m LST=GMT+99 hours *NT= +8
09/98–12/00



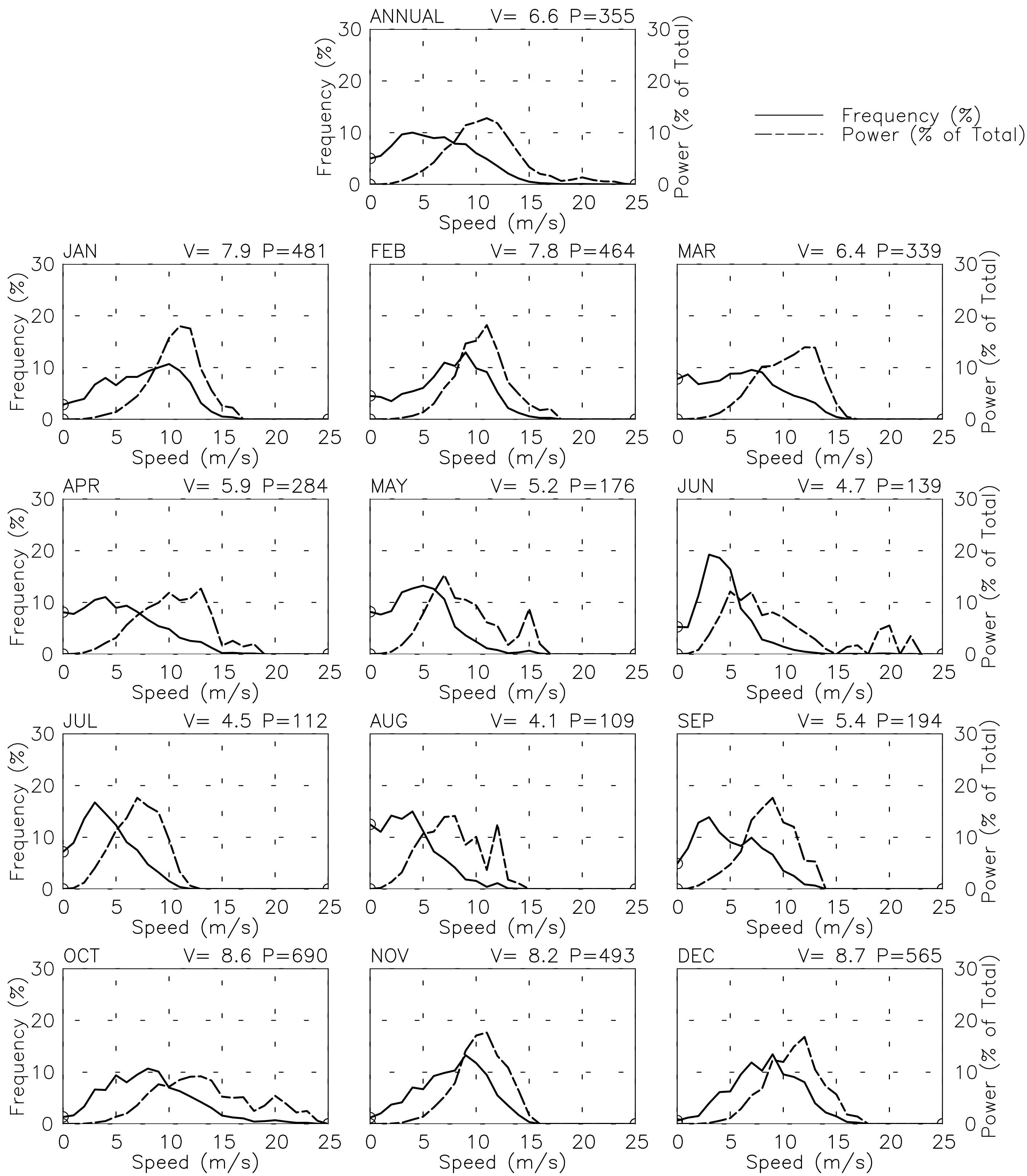
Wed Sep 4 13:56:46 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

Aozi 40m - 000020

23° 36' N 117° 25' E - Elev 55m LST=GMT+99 hours *NT= +8

09/98-12/00



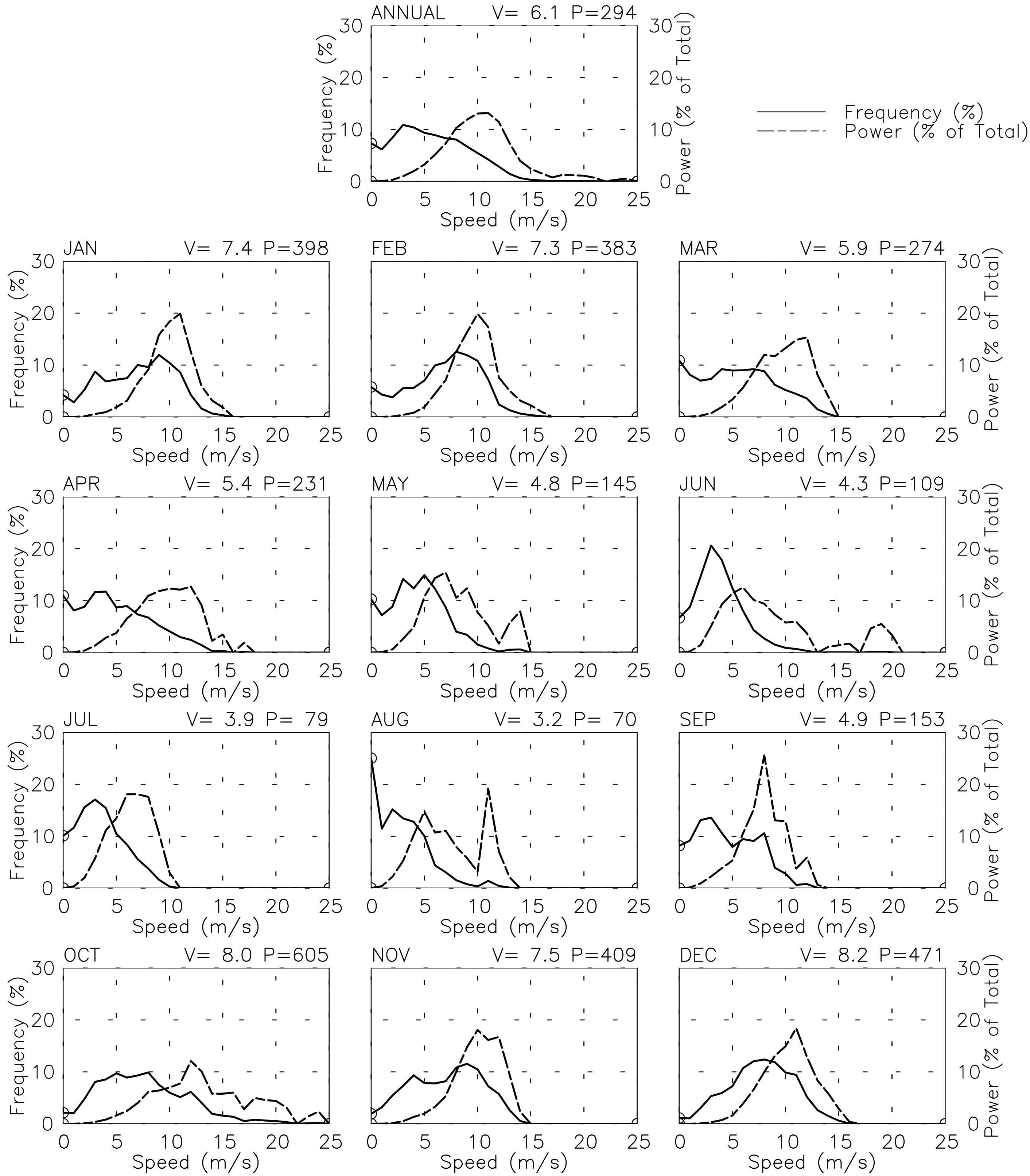
Wed Sep 4 13:56:20 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

Aozi 25m – 000021

23° 36' N 117° 25' E – Elev 55m LST=GMT+99 hours *NT= +8

09/98–12/00



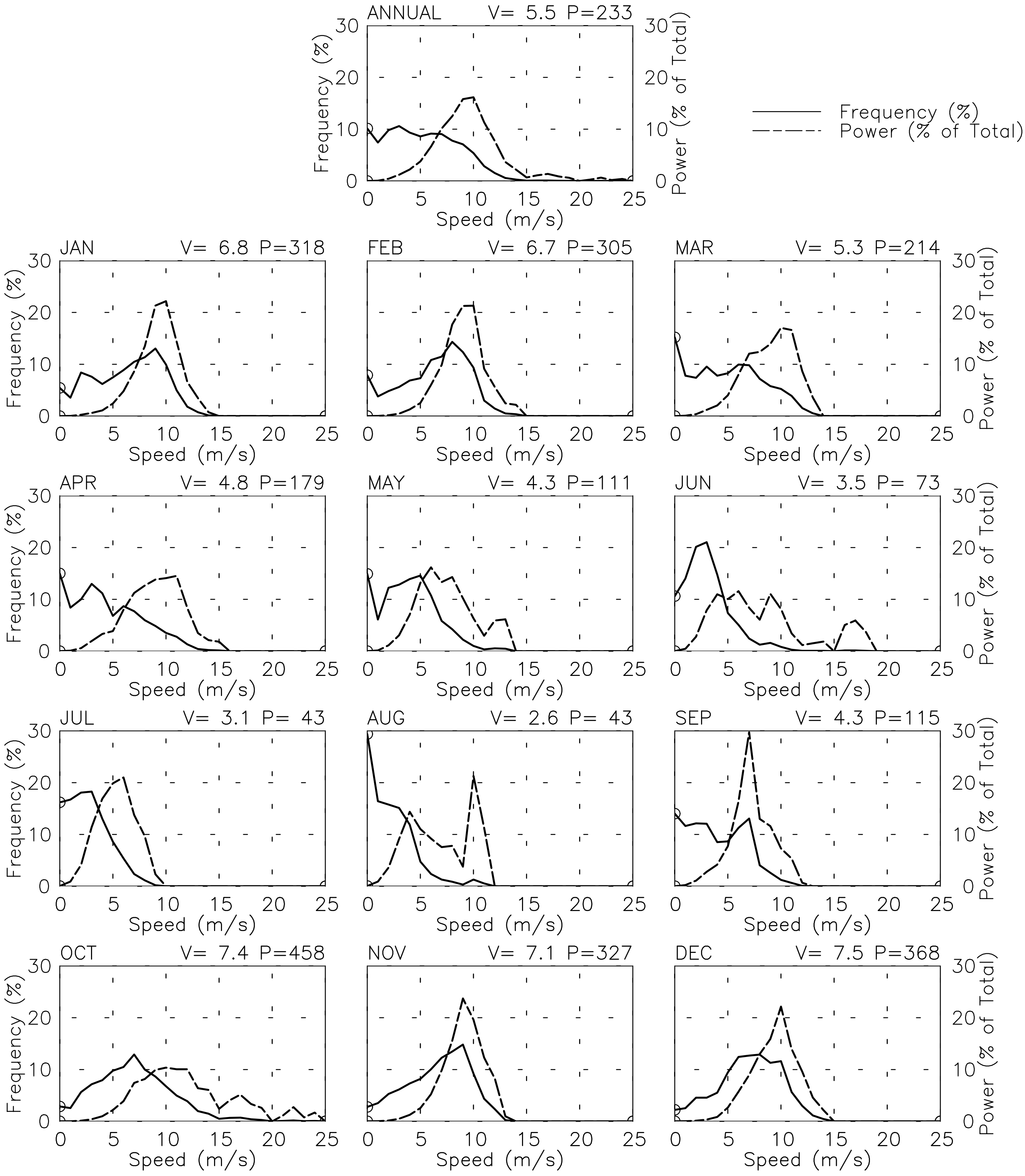
Wed Sep 4 13:56:34 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

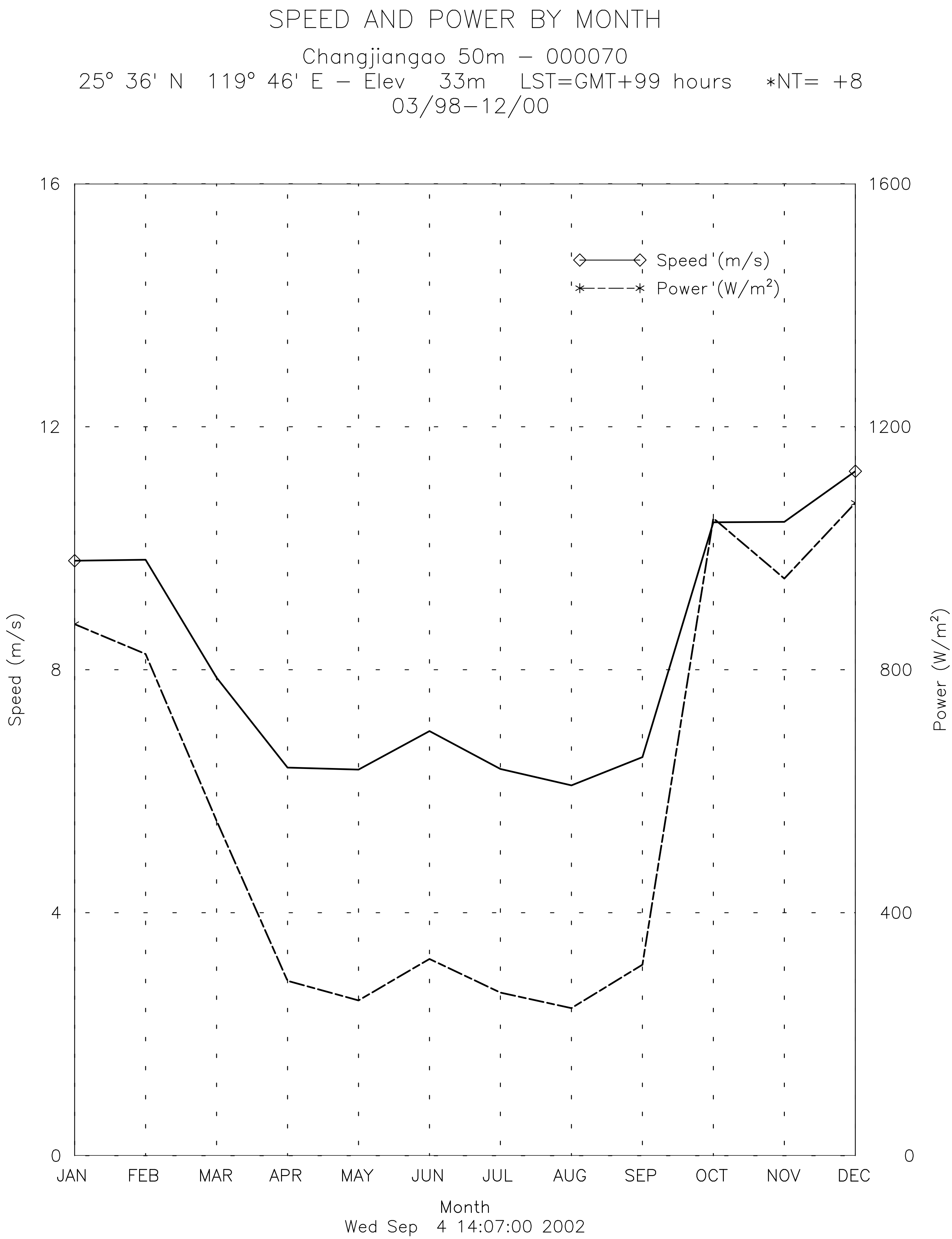
Aozi 10m - 000022

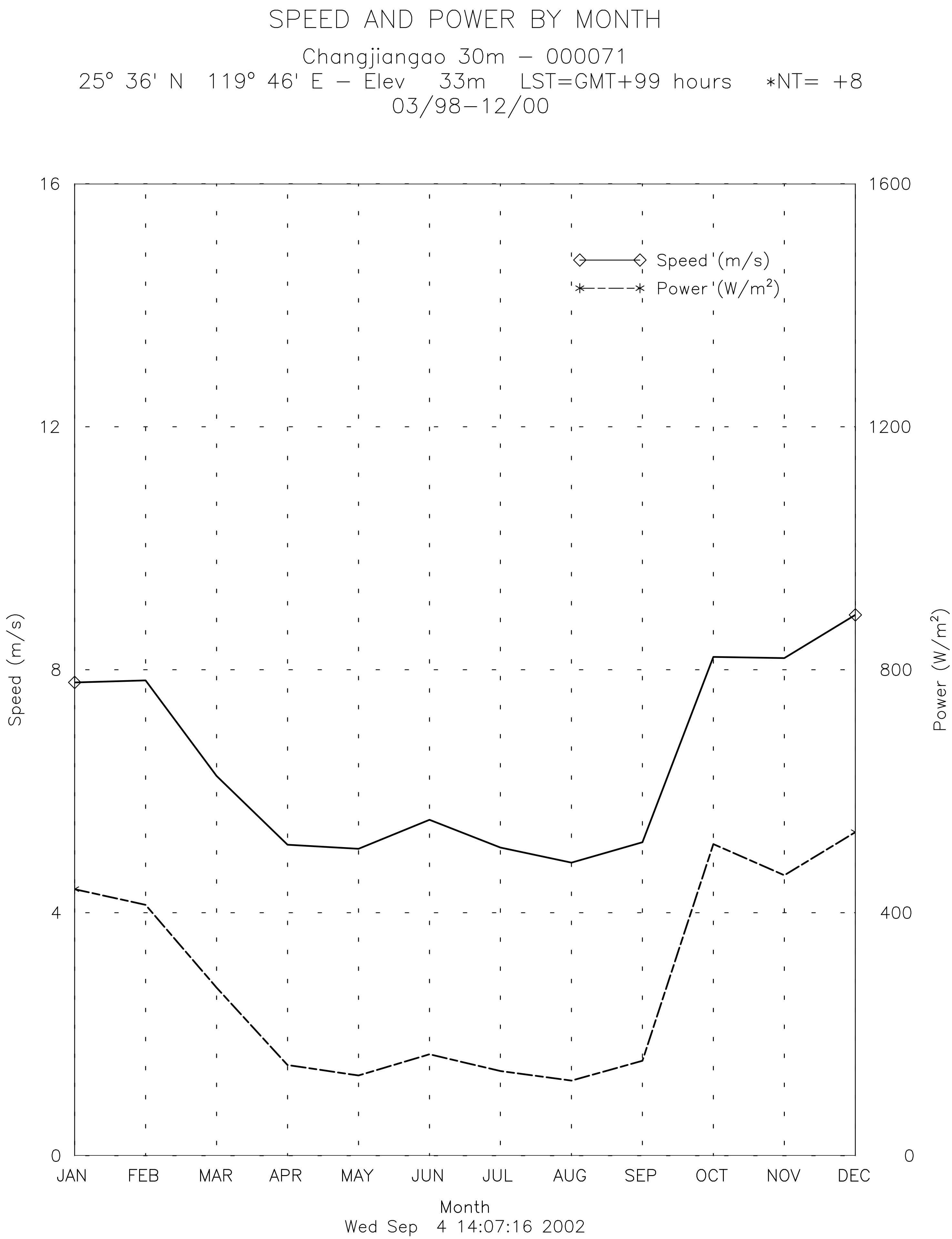
23° 36' N 117° 25' E - Elev 55m LST=GMT+99 hours *NT= +8

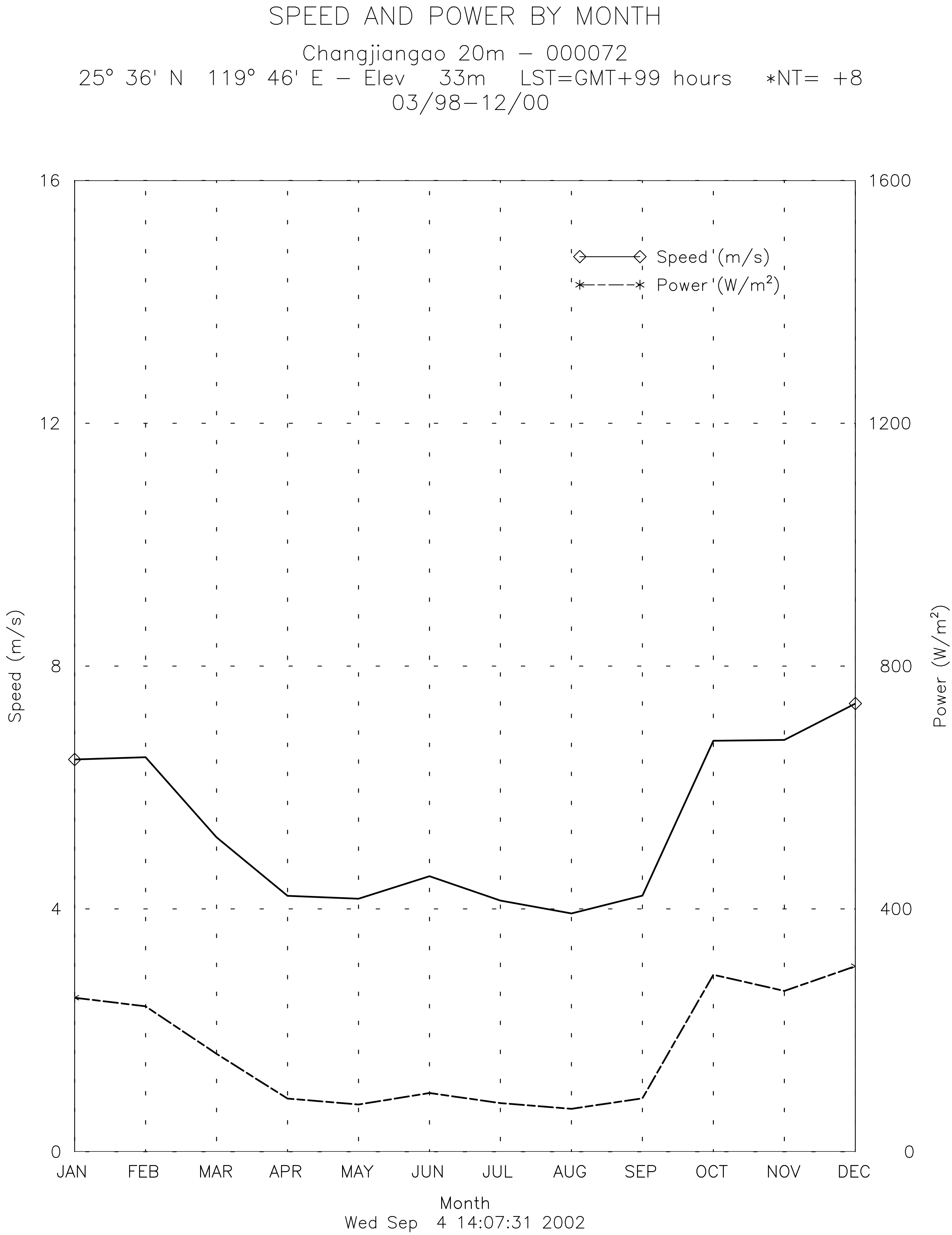
09/98-12/00

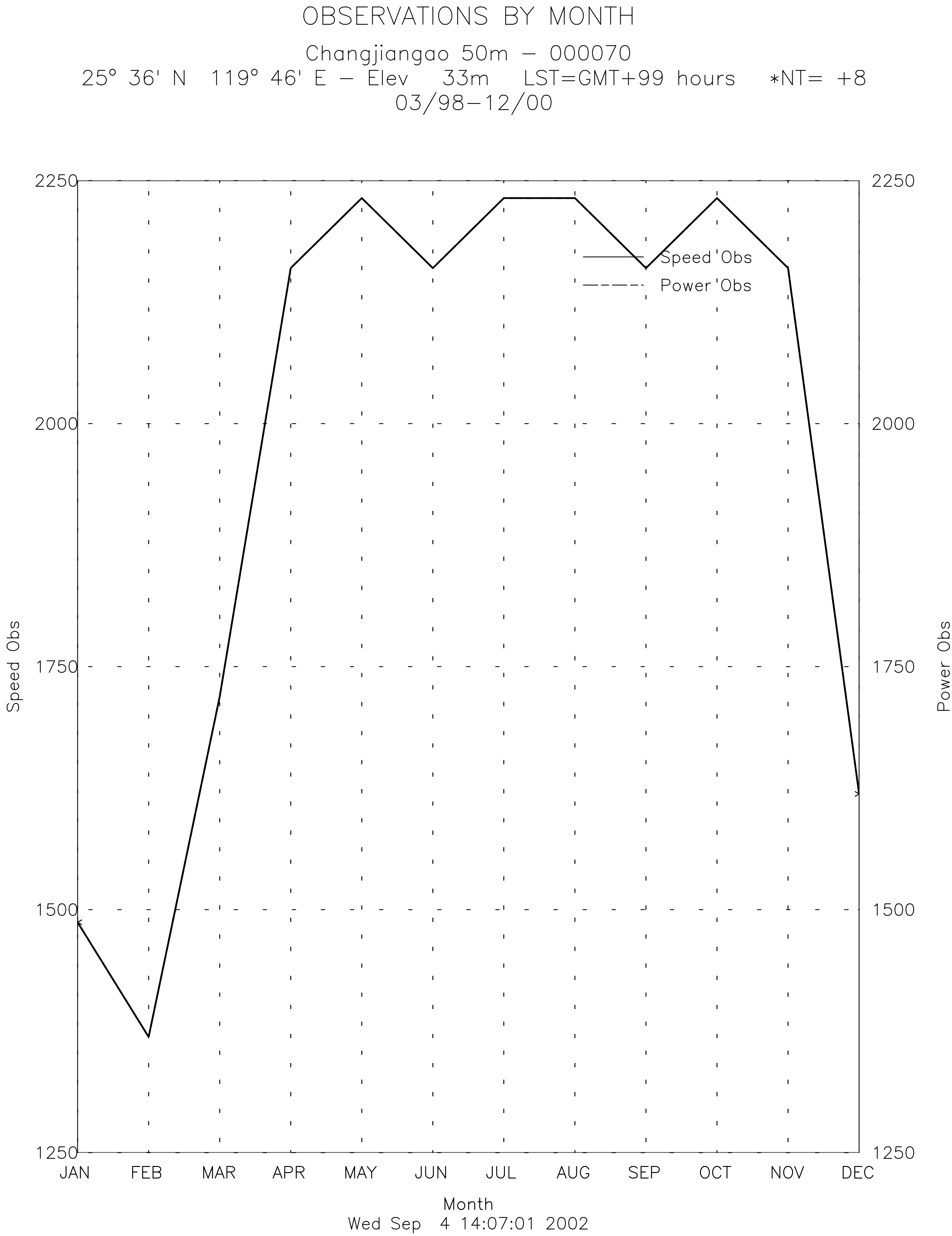


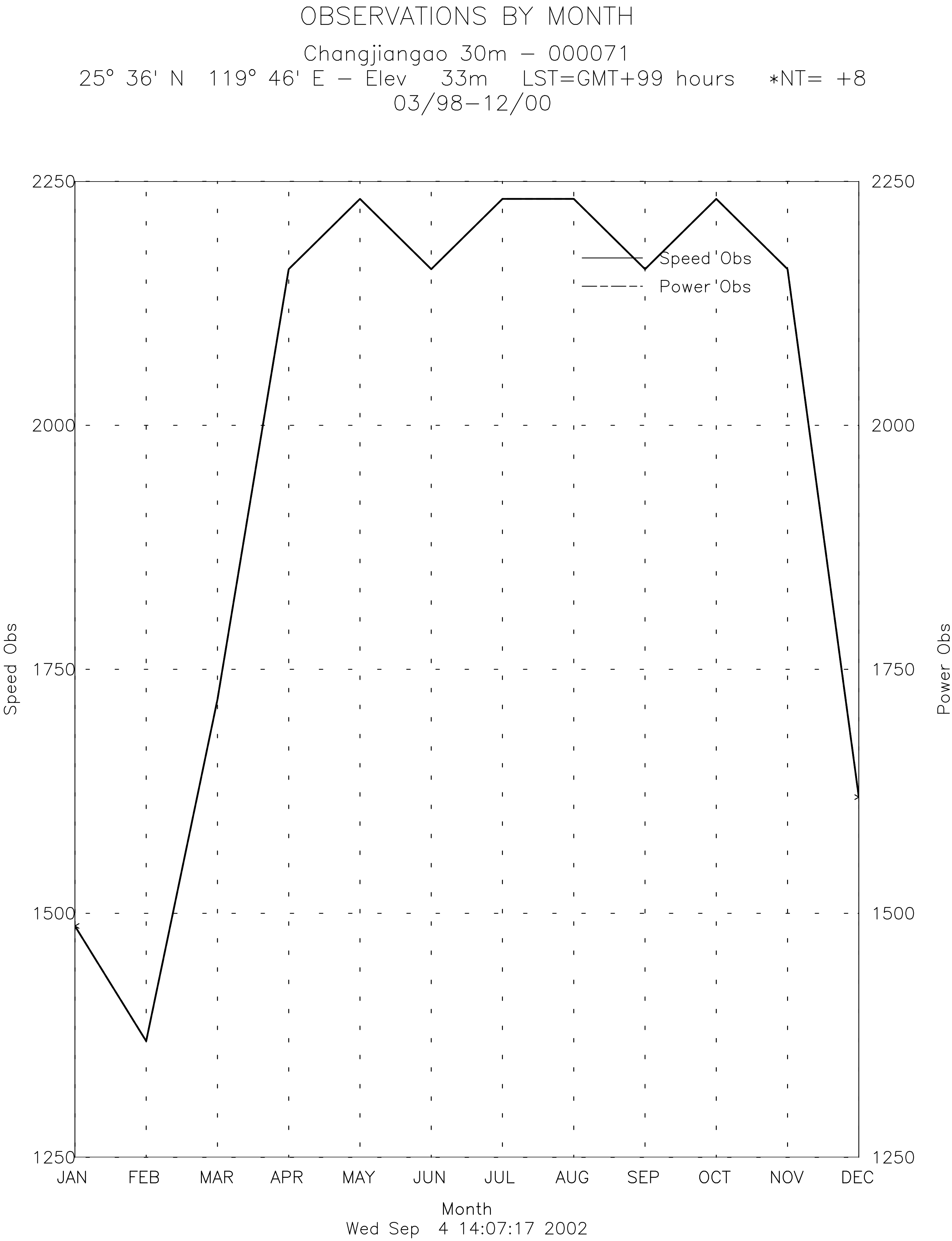
Wed Sep 4 13:56:49 2002

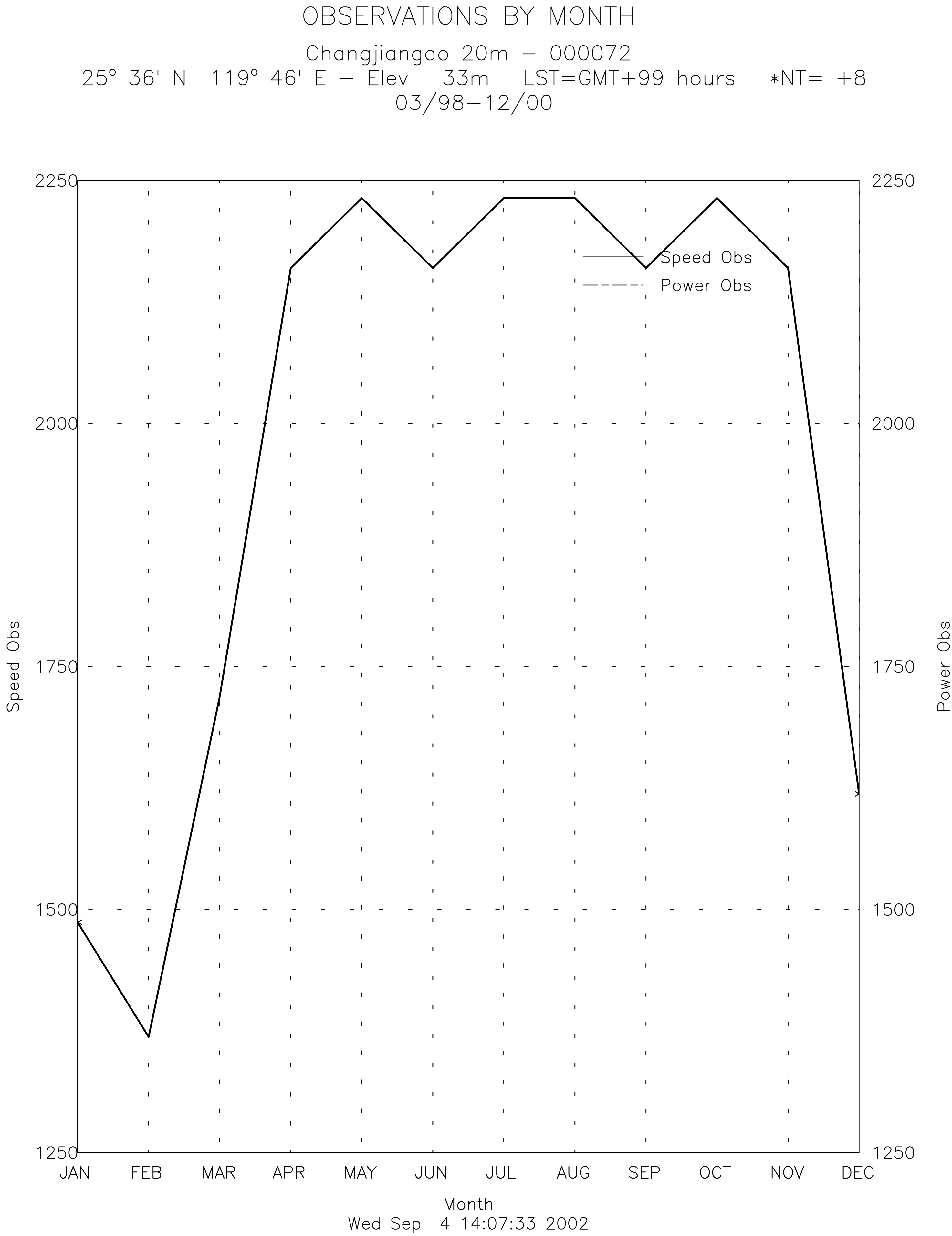

SPEED AND POWER BY MONTH
Changjiangao 50m – 000070
25° 36' N 119° 46' E – Elev 33m LST=GMT+99 hours *NT= +8
03/98–12/00
Speed (m/s)
Power (W/m²)
16
12
8
4
0
1600
1200
800
400
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 14:07:00 2002


SPEED AND POWER BY MONTH
Changjiangao 30m – 000071
25° 36' N 119° 46' E – Elev 33m LST=GMT+99 hours *NT= +8
03/98–12/00
Speed (m/s)
Power (W/m²)
16
12
8
4
0
1600
1200
800
400
0
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
Month
Wed Sep 4 14:07:16 2002


SPEED AND POWER BY MONTH
Changjiangao 20m - 000072
25° 36' N 119° 46' E - Elev 33m LST=GMT+99 hours *NT= +8
03/98-12/00
Speed (m/s)
Power (W/m²)
16
12
8
4
0
1600
1200
800
400
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 14:07:31 2002


OBSERVATIONS BY MONTH
Changjiangao 50m - 000070
25° 36' N 119° 46' E - Elev 33m LST=GMT+99 hours *NT= +8
03/98-12/00
Speed'Obs
Power'Obs
2250
2000
1750
1500
1250
Speed Obs
Power Obs
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 14:07:01 2002


OBSERVATIONS BY MONTH
Changjiangao 30m - 000071
25° 36' N 119° 46' E - Elev 33m LST=GMT+99 hours *NT= +8
03/98-12/00
Speed Obs
Power Obs
2250
2000
1750
1500
1250
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 14:07:17 2002

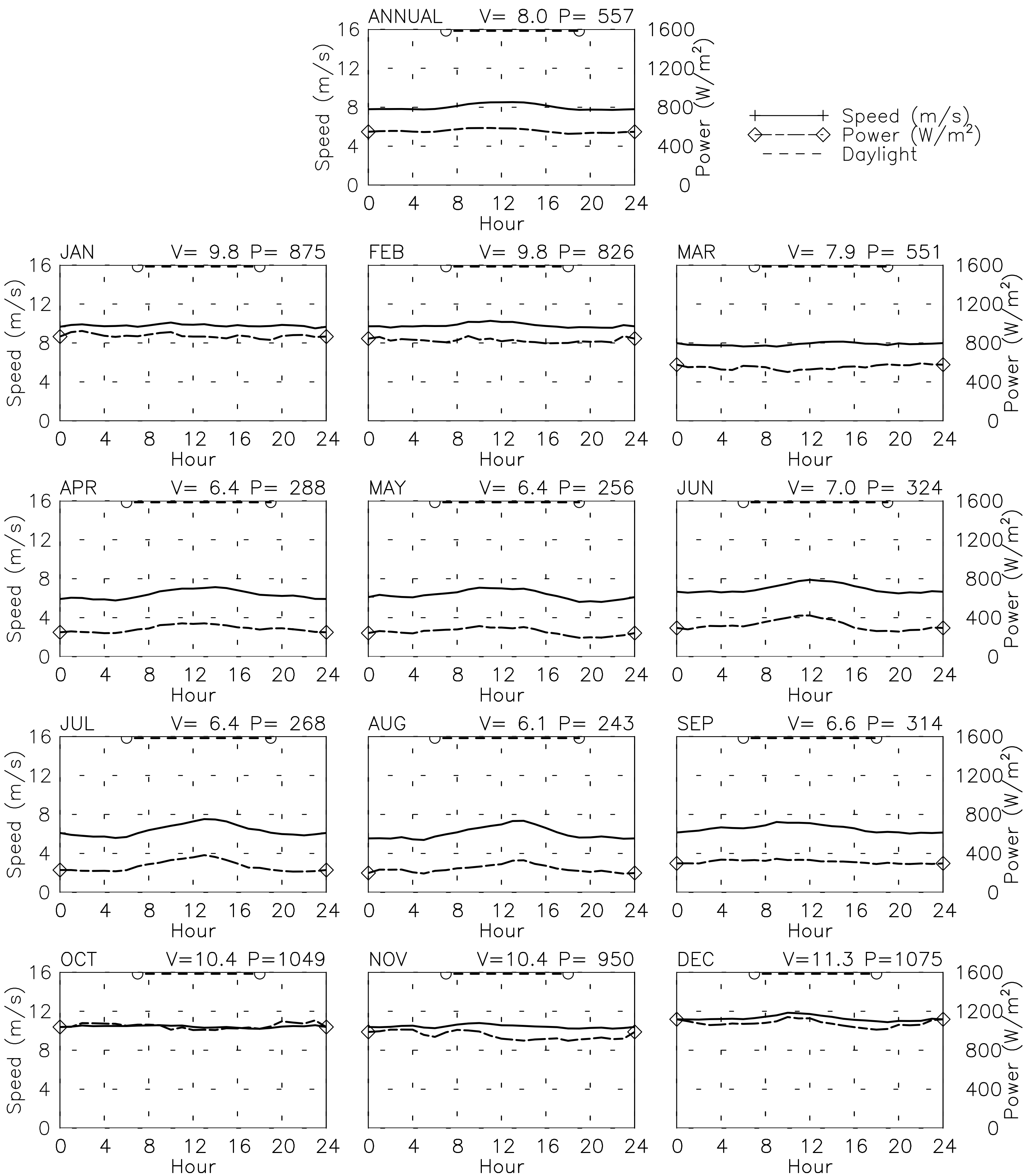

OBSERVATIONS BY MONTH
Changjiangao 20m - 000072
25° 36' N 119° 46' E - Elev 33m LST=GMT+99 hours *NT= +8
03/98-12/00
Speed'Obs
Power'Obs
2250
2000
1750
1500
1250
Speed Obs
Power Obs
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 14:07:33 2002

SPEED AND POWER BY HOUR

Changjiangao 50m – 000070

25° 36' N 119° 46' E – Elev 33m LST=GMT+99 hours *NT= +8

03/98–12/00



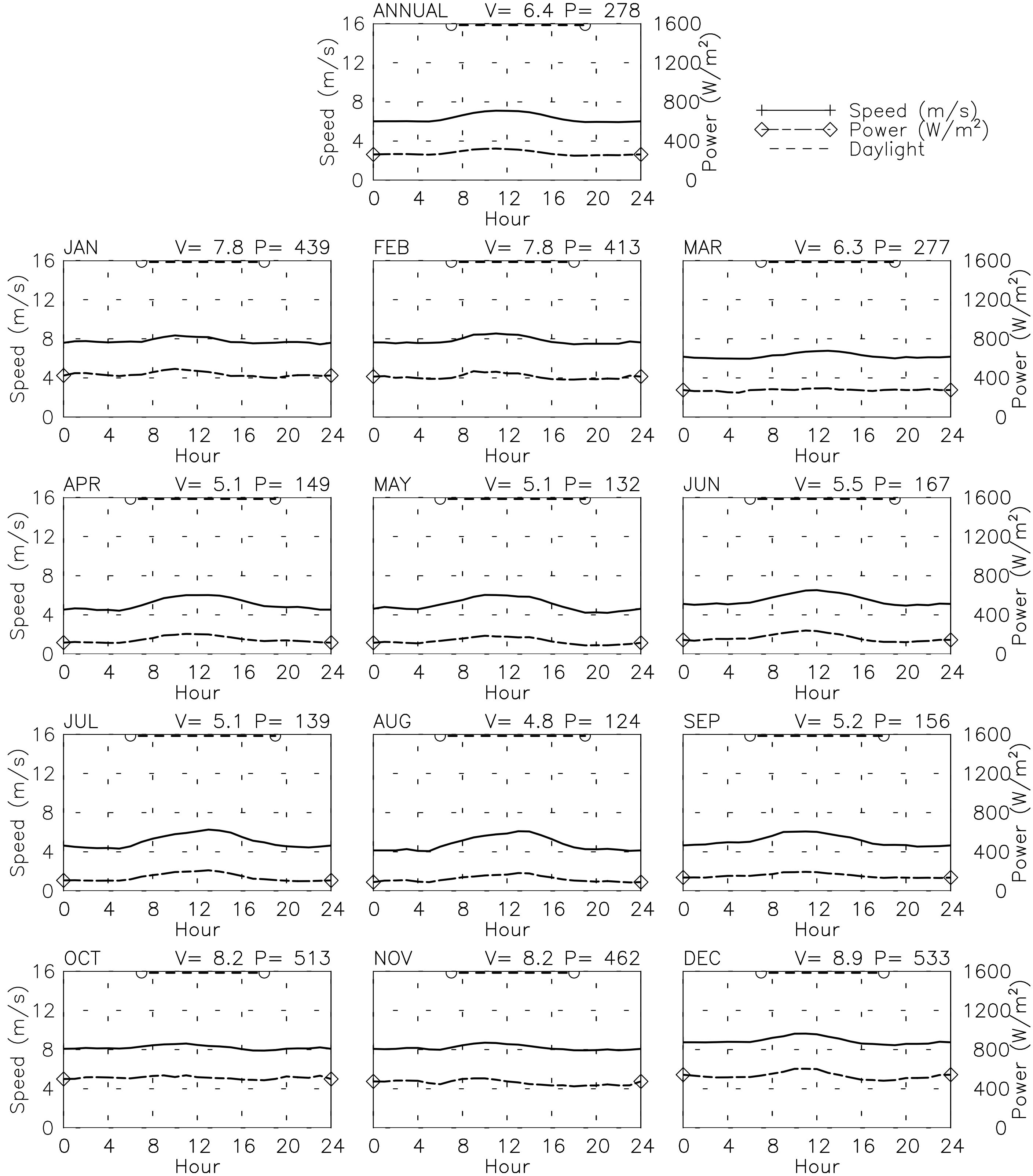
Wed Sep 4 14:07:03 2002

SPEED AND POWER BY HOUR

Changjiangao 30m – 000071

25° 36' N 119° 46' E – Elev 33m LST=GMT+99 hours *NT= +8

03/98–12/00



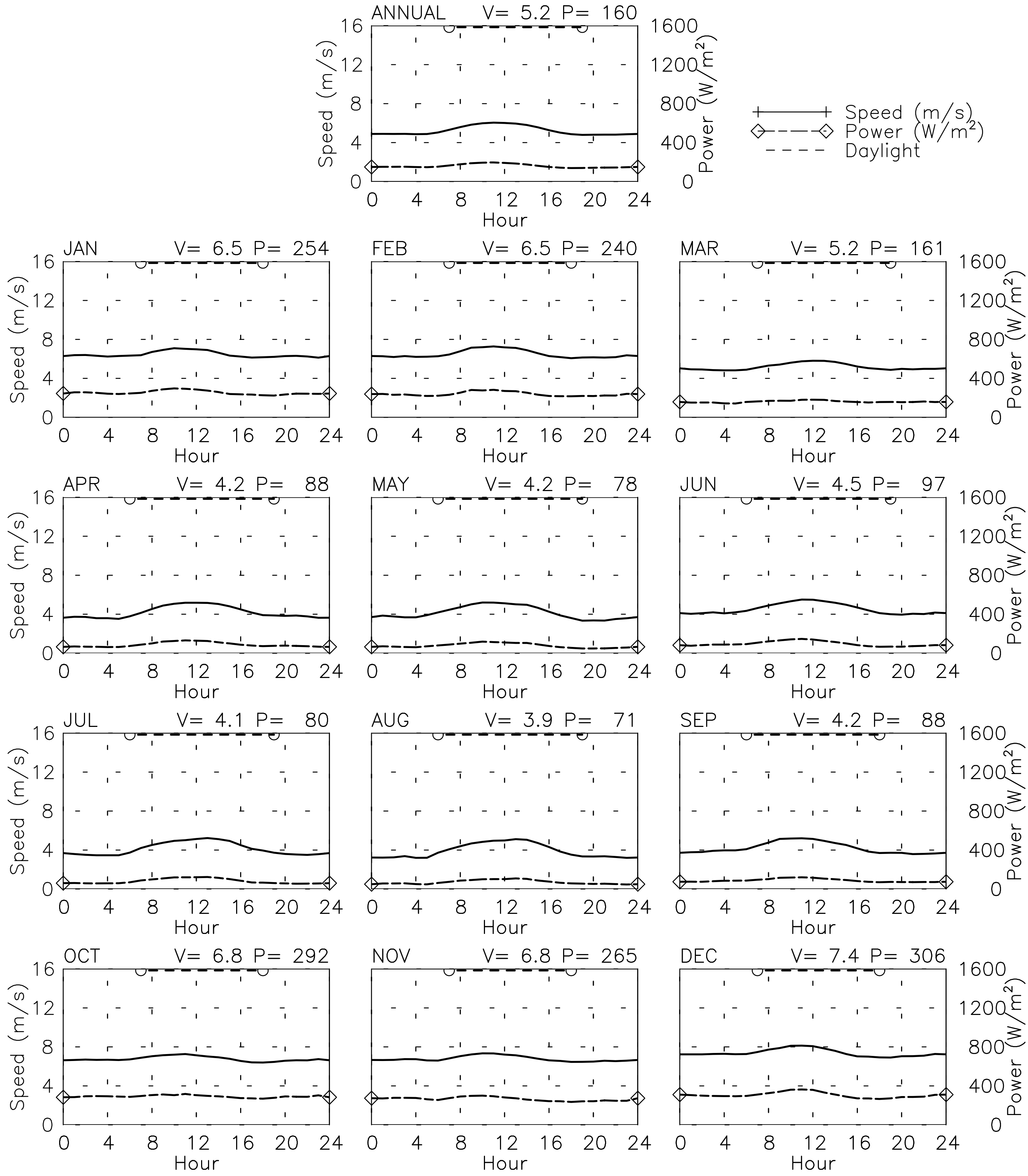
Wed Sep 4 14:07:18 2002

SPEED AND POWER BY HOUR

Changjiangao 20m - 000072

25° 36' N 119° 46' E - Elev 33m LST=GMT+99 hours *NT= +8

03/98-12/00



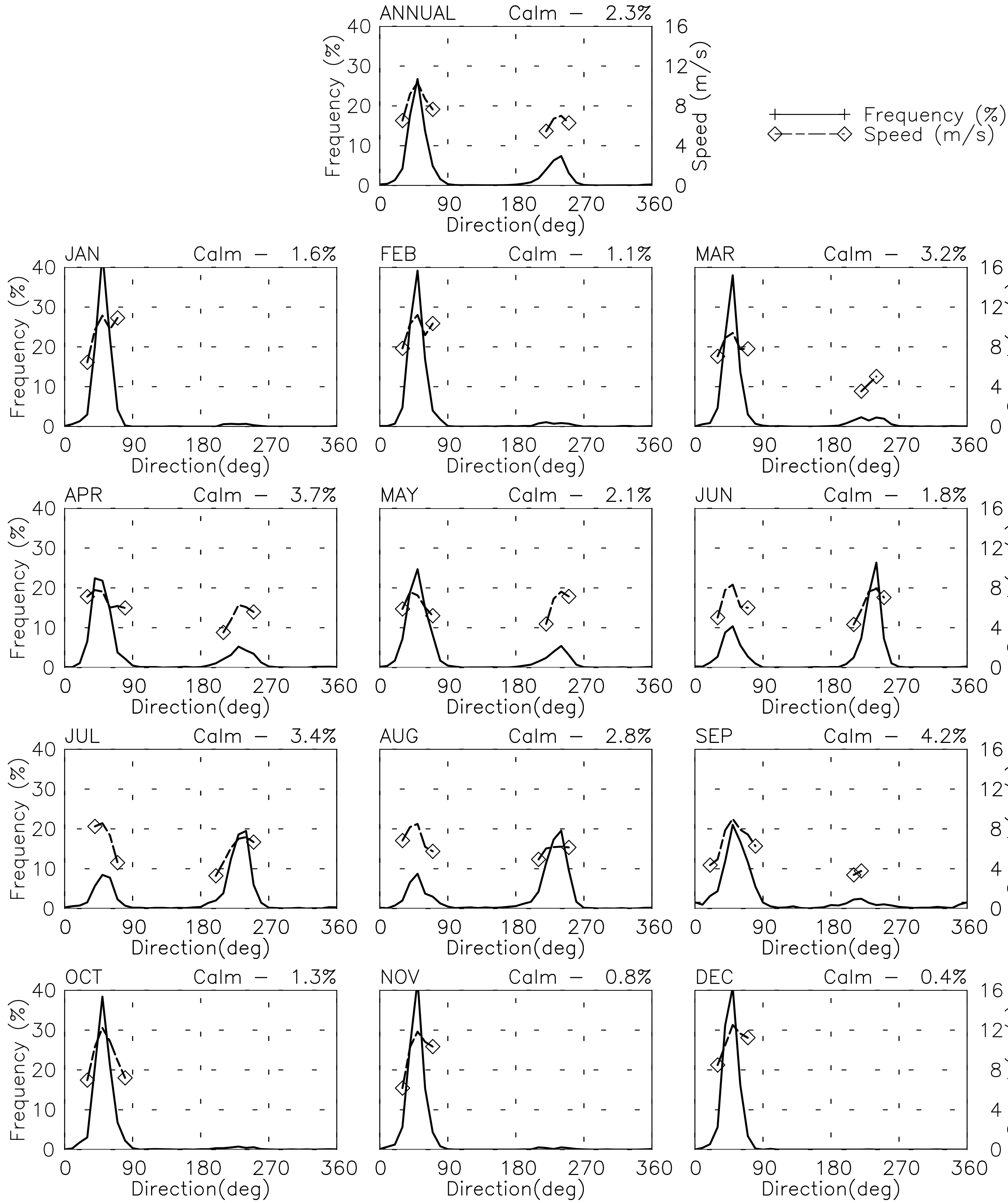
Wed Sep 4 14:07:34 2002

FREQUENCY AND SPEED BY DIRECTION

Changjiangao 50m – 000070

25° 36' N 119° 46' E – Elev 33m LST=GMT+99 hours *NT= +8

03/98–12/00



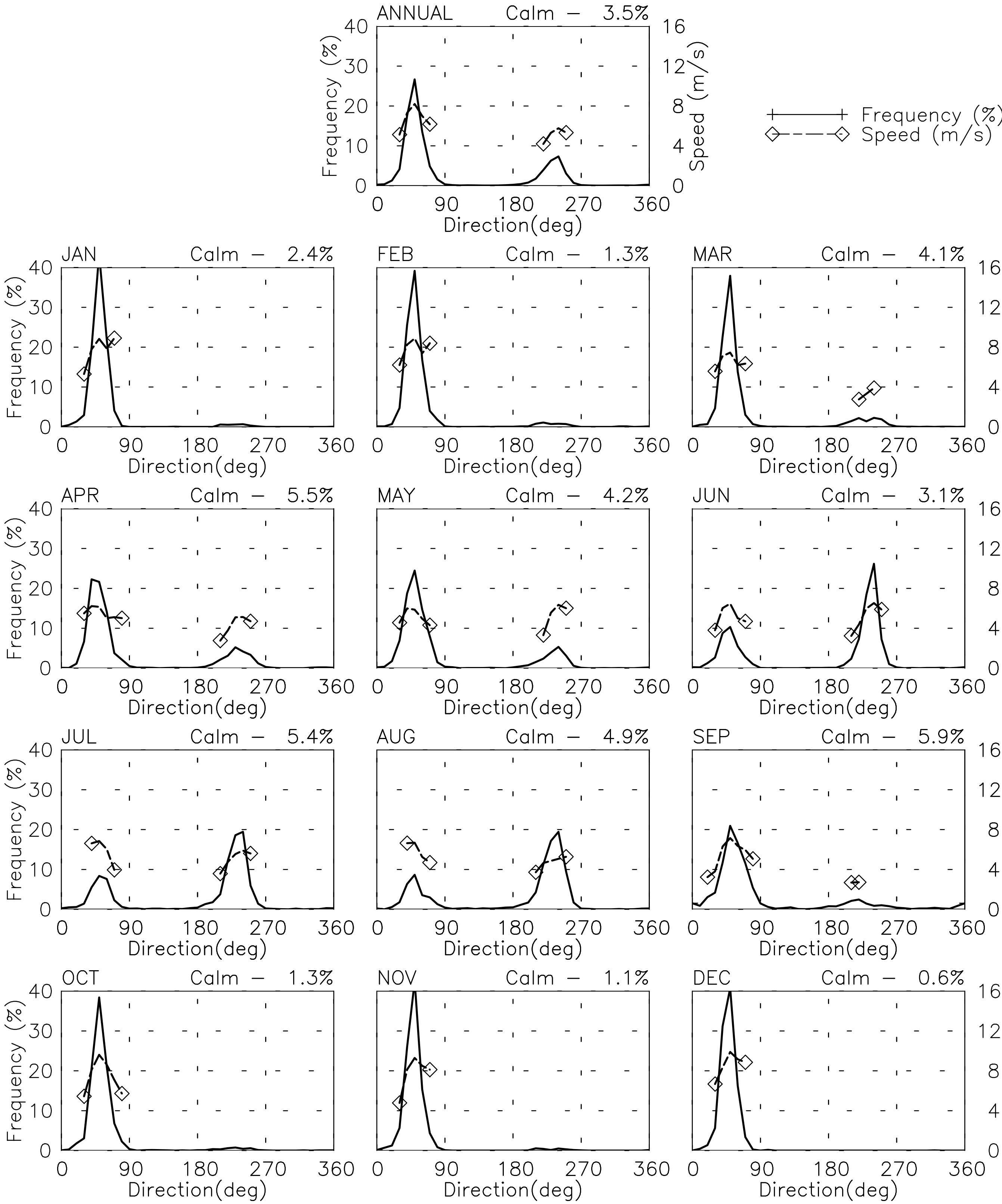
Wed Sep 4 14:07:06 2002

FREQUENCY AND SPEED BY DIRECTION

Changjiangao 30m – 000071

25° 36' N 119° 46' E – Elev 33m LST=GMT+99 hours *NT= +8

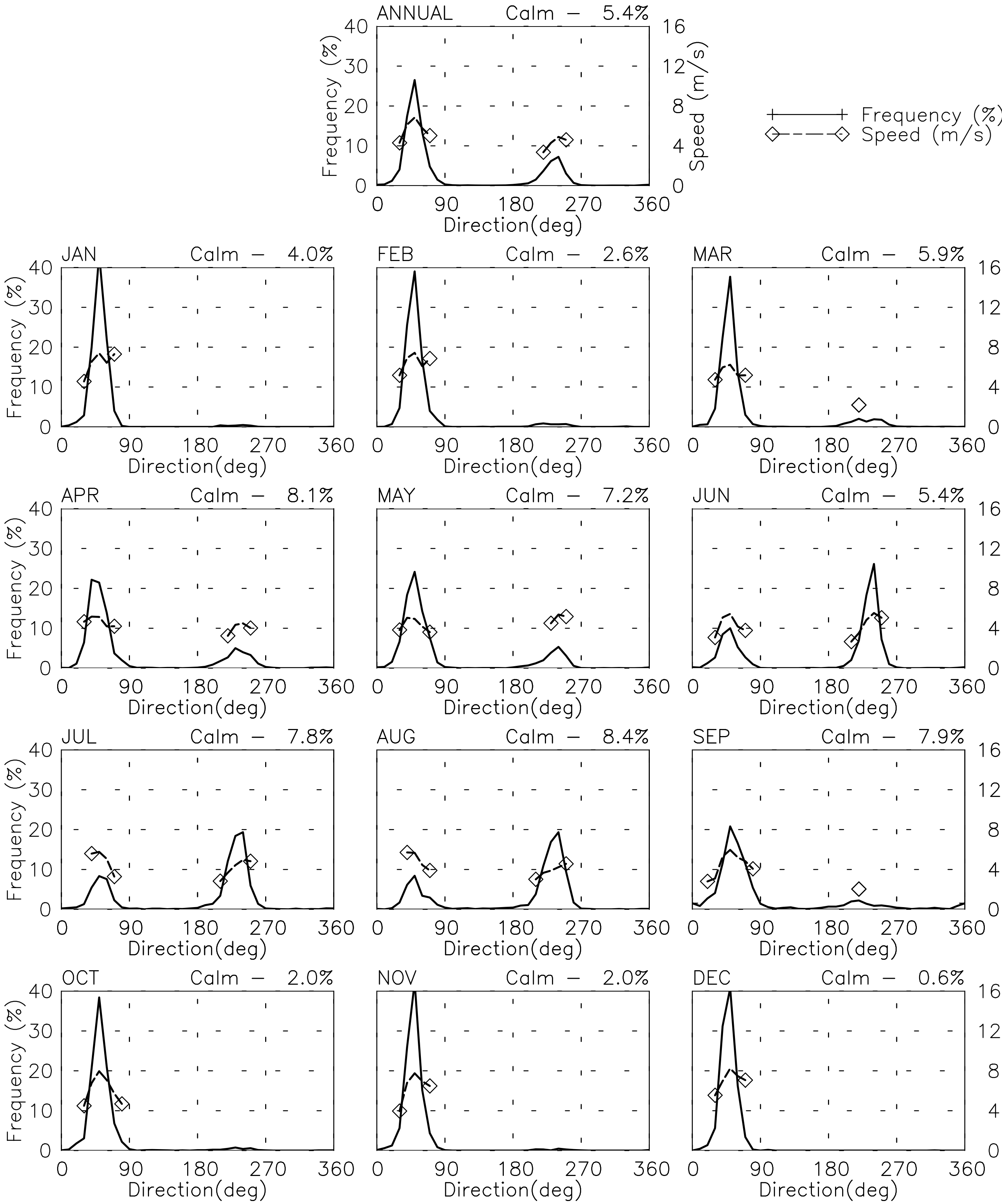
03/98–12/00



Wed Sep 4 14:07:21 2002

FREQUENCY AND SPEED BY DIRECTION

Changjiangao 20m – 000072
25° 36' N 119° 46' E – Elev 33m LST=GMT+99 hours *NT= +8
03/98–12/00



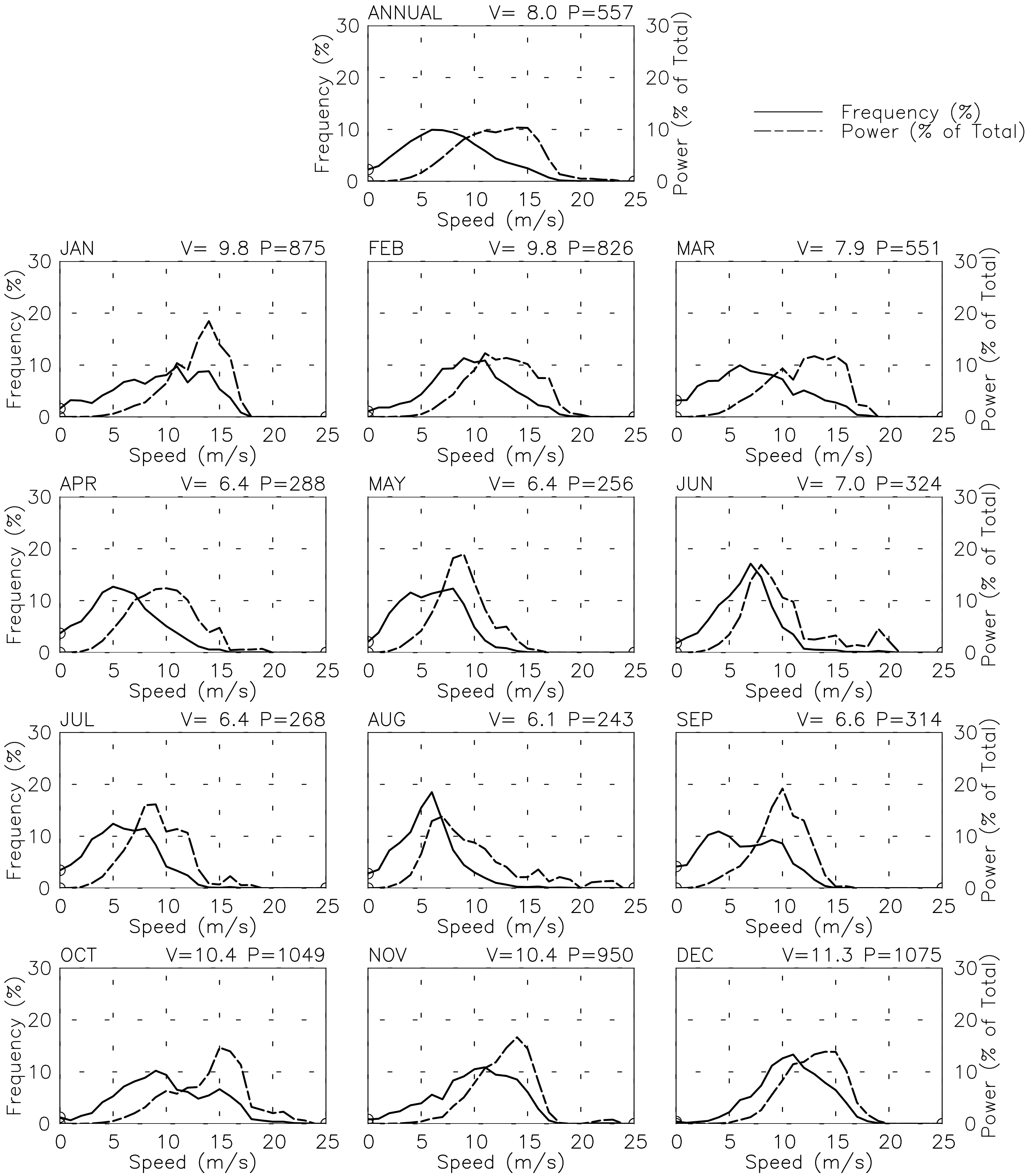
Wed Sep 4 14:07:37 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

Changjiangao 50m − 000070

25° 36' N 119° 46' E − Elev 33m LST=GMT+99 hours *NT= +8

03/98−12/00



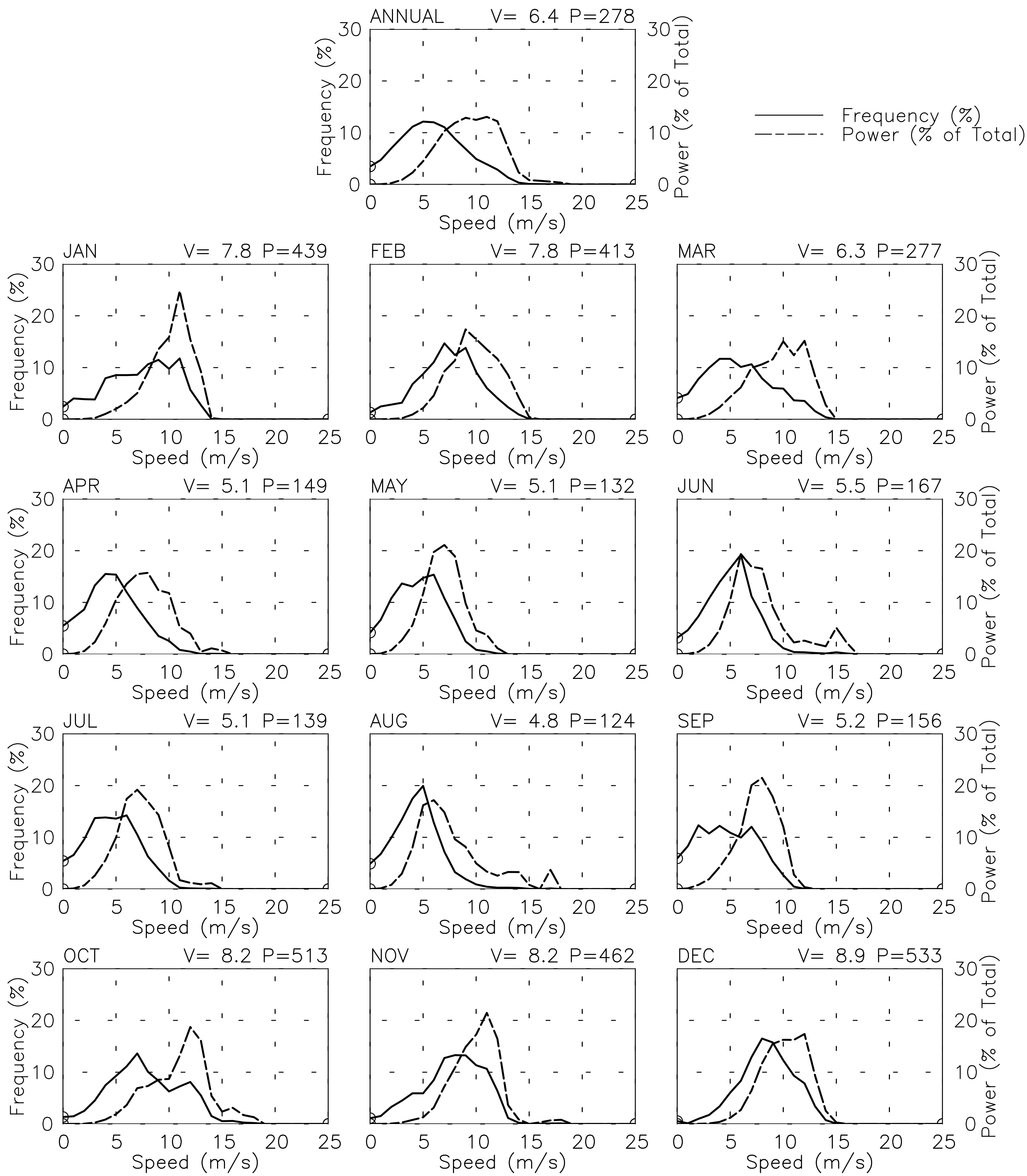
Wed Sep 4 14:07:09 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

Changjiangao 30m – 000071

25° 36' N 119° 46' E – Elev 33m LST=GMT+99 hours *NT= +8

03/98–12/00



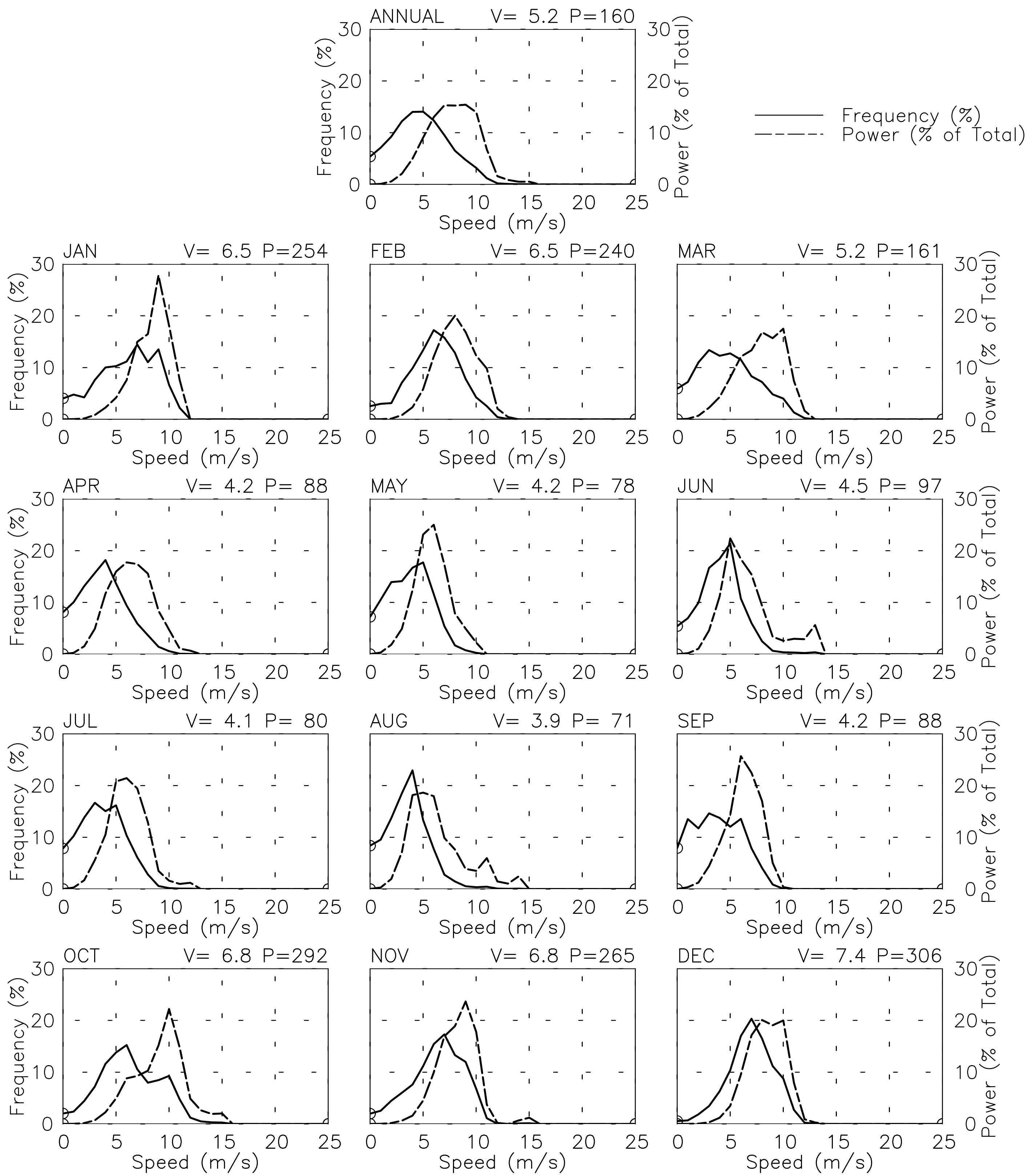
Wed Sep 4 14:07:24 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

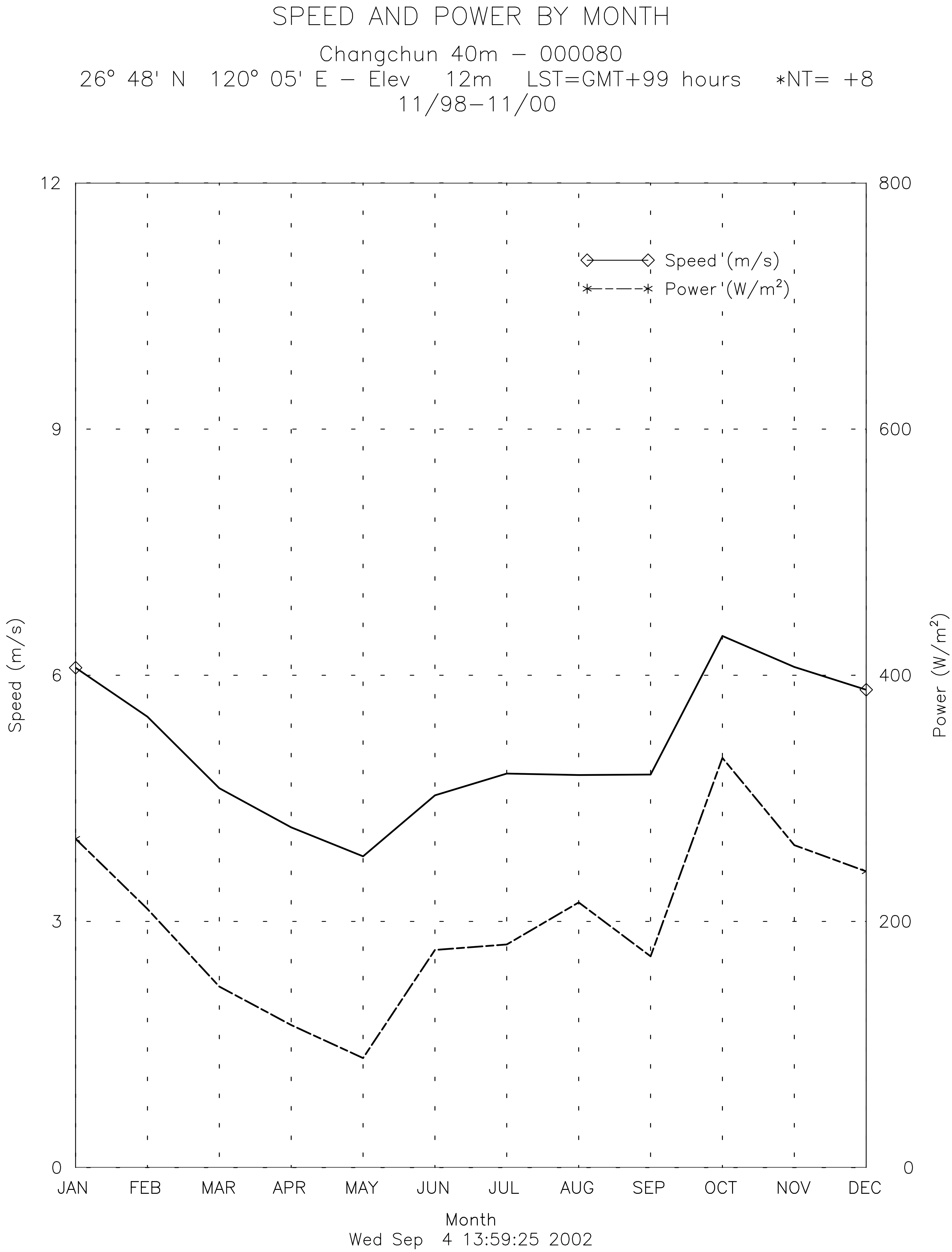
Changjiangao 20m – 000072

25° 36' N 119° 46' E – Elev 33m LST=GMT+99 hours *NT= +8

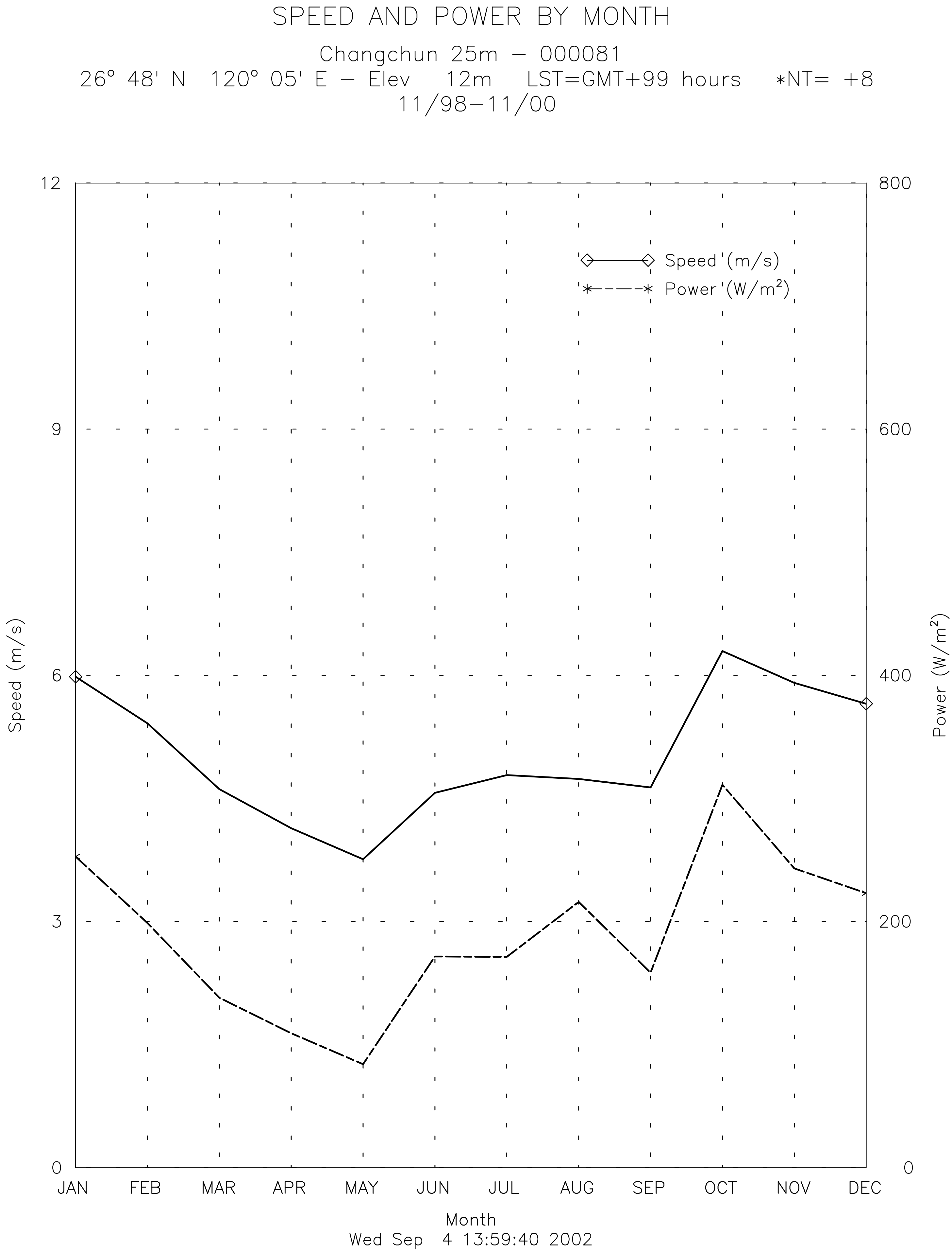
03/98–12/00



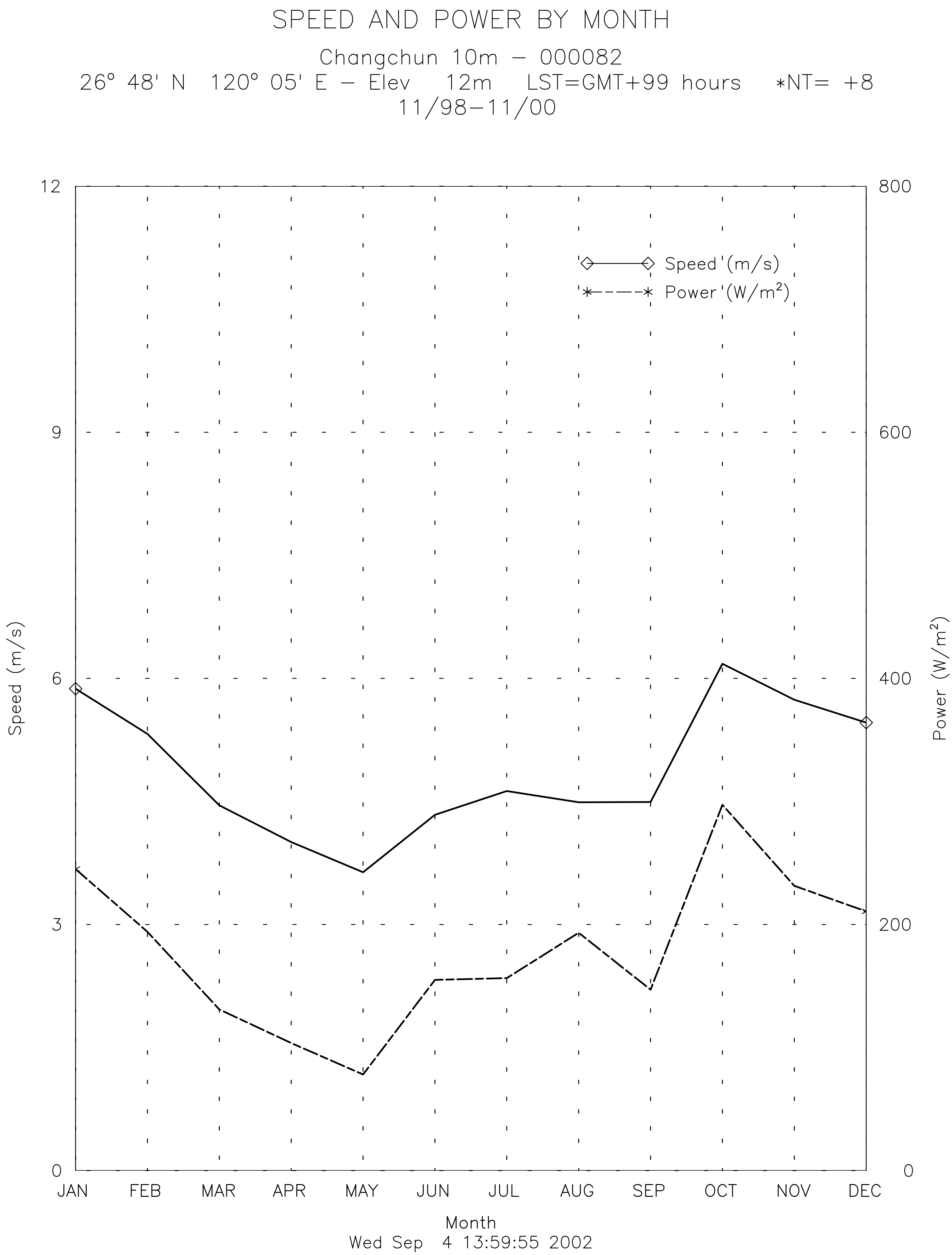
Wed Sep 4 14:07:40 2002



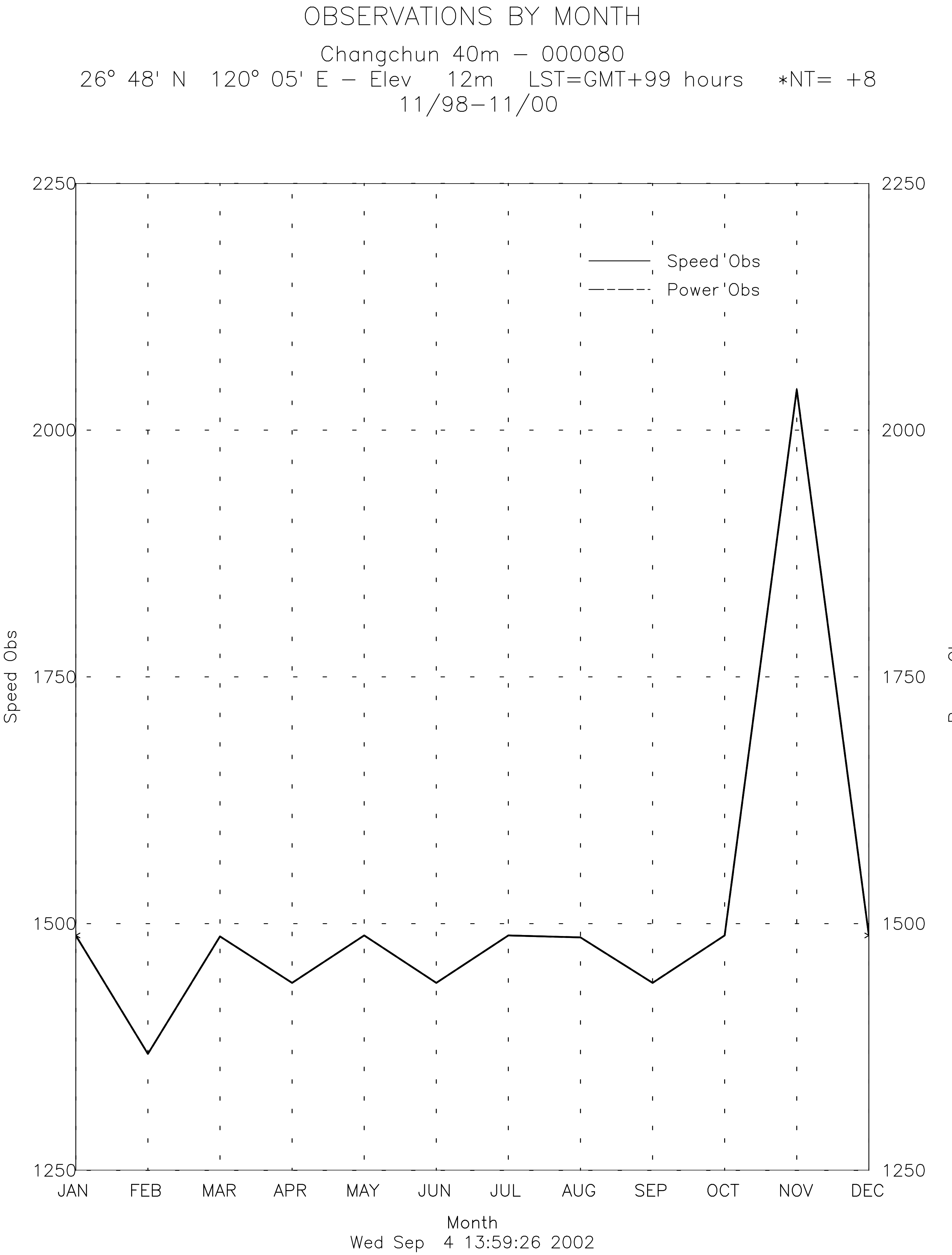
SPEED AND POWER BY MONTH
Changchun 40m - 000080
26° 48' N 120° 05' E - Elev 12m LST=GMT+99 hours *NT= +8
11/98-11/00
Speed (m/s)
Power (W/m²)
12
9
6
3
0
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:59:25 2002

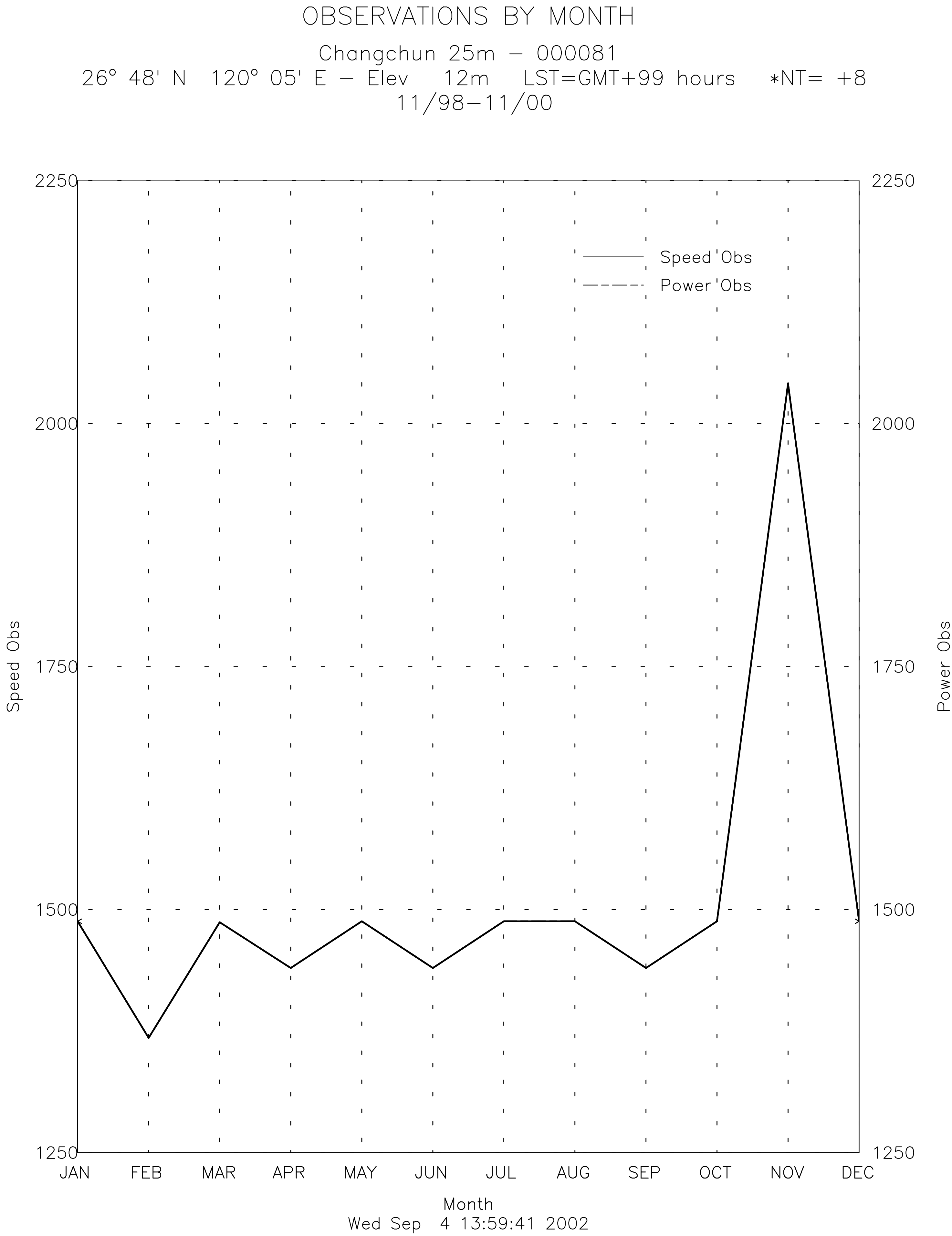


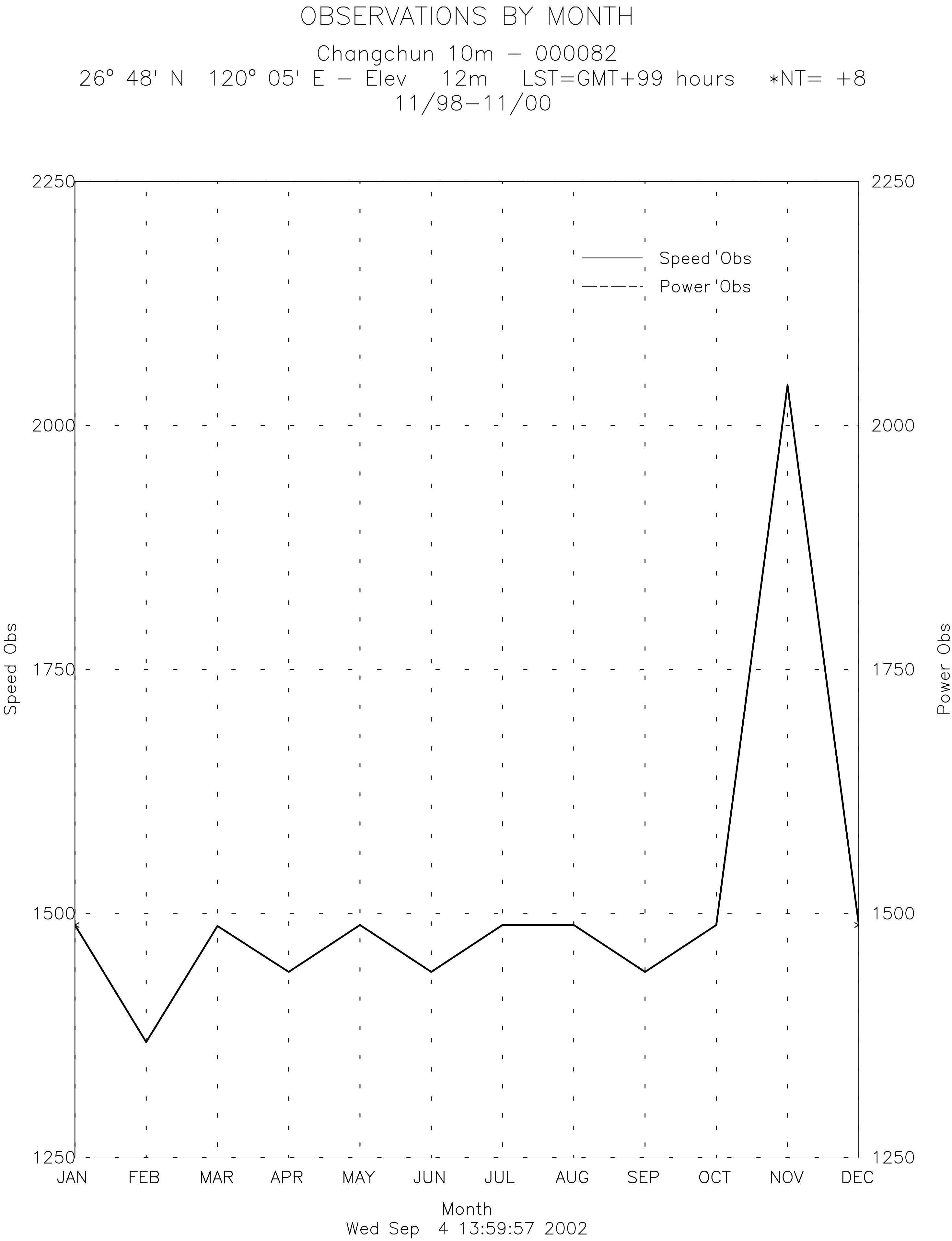
SPEED AND POWER BY MONTH
Changchun 25m - 000081
26° 48' N 120° 05' E - Elev 12m LST=GMT+99 hours *NT= +8
11/98-11/00
Speed (m/s)
Power (W/m²)
Speed (m/s)
Power (W/m²)
12
9
6
3
0
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:59:40 2002



SPEED AND POWER BY MONTH
Changchun 10m - 000082
26° 48' N 120° 05' E - Elev 12m LST=GMT+99 hours *NT= +8
11/98-11/00
Speed (m/s)
Power (W/m²)
Speed (m/s)
Power (W/m²)
12
9
6
3
0
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:59:55 2002


OBSERVATIONS BY MONTH
Changchun 40m - 000080
26° 48' N 120° 05' E - Elev 12m LST=GMT+99 hours *NT= +8
11/98-11/00
Speed'Obs
Power'Obs
2250
2000
1750
1500
1250
Speed Obs
Power Obs
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:59:26 2002

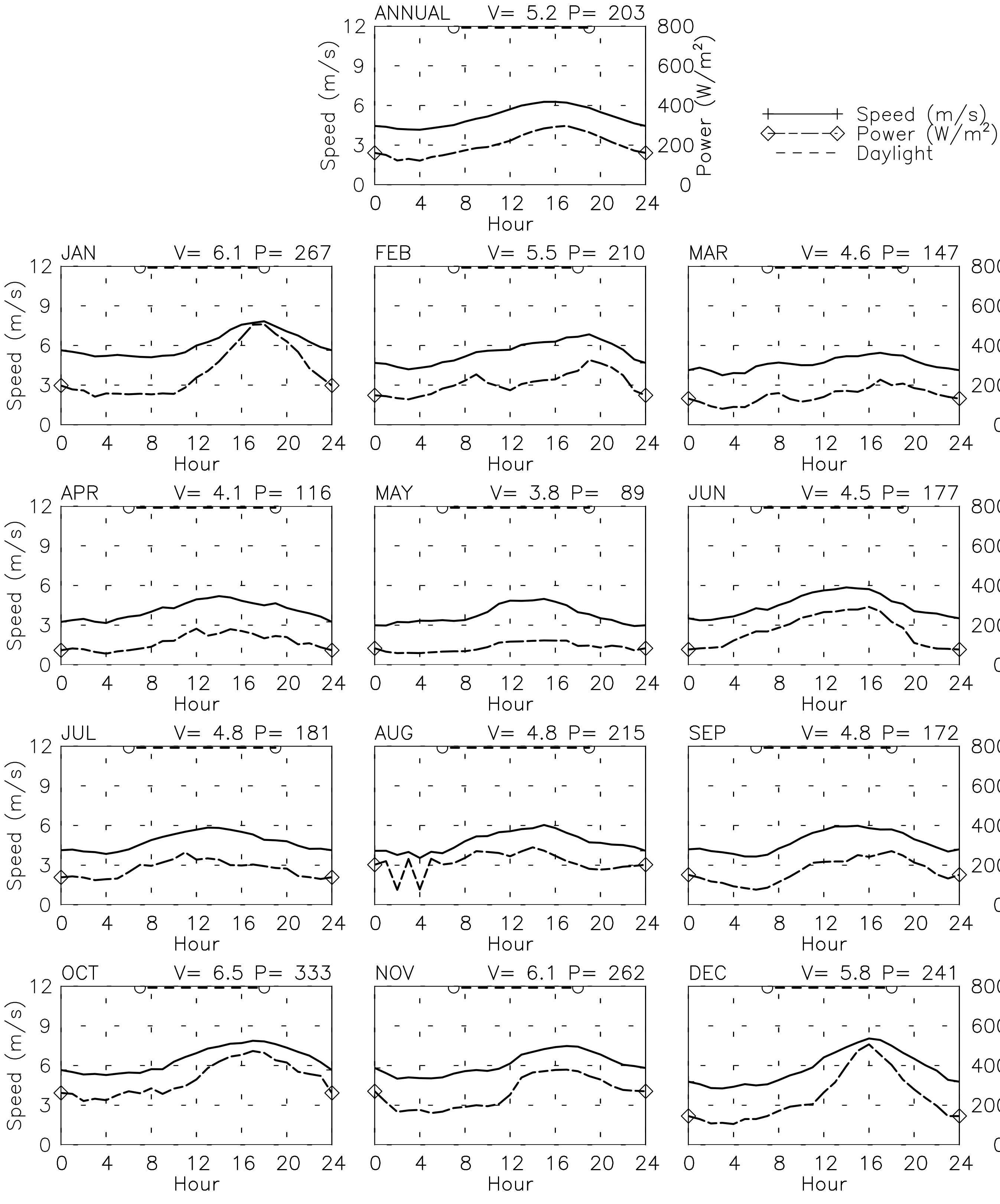

OBSERVATIONS BY MONTH
Changchun 25m - 000081
26° 48' N 120° 05' E - Elev 12m LST=GMT+99 hours *NT= +8
11/98-11/00
Speed'Obs
Power'Obs
Speed Obs
Power Obs
2250
2000
1750
1500
1250
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:59:41 2002



OBSERVATIONS BY MONTH
Changchun 10m - 000082
26° 48' N 120° 05' E - Elev 12m LST=GMT+99 hours *NT= +8
11/98-11/00
Speed'Obs
Power'Obs
2250
2000
1750
1500
1250
Speed Obs
Power Obs
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:59:57 2002

SPEED AND POWER BY HOUR

Changchun 40m – 000080
26° 48' N 120° 05' E – Elev 12m LST=GMT+99 hours *NT= +8
11/98–11/00



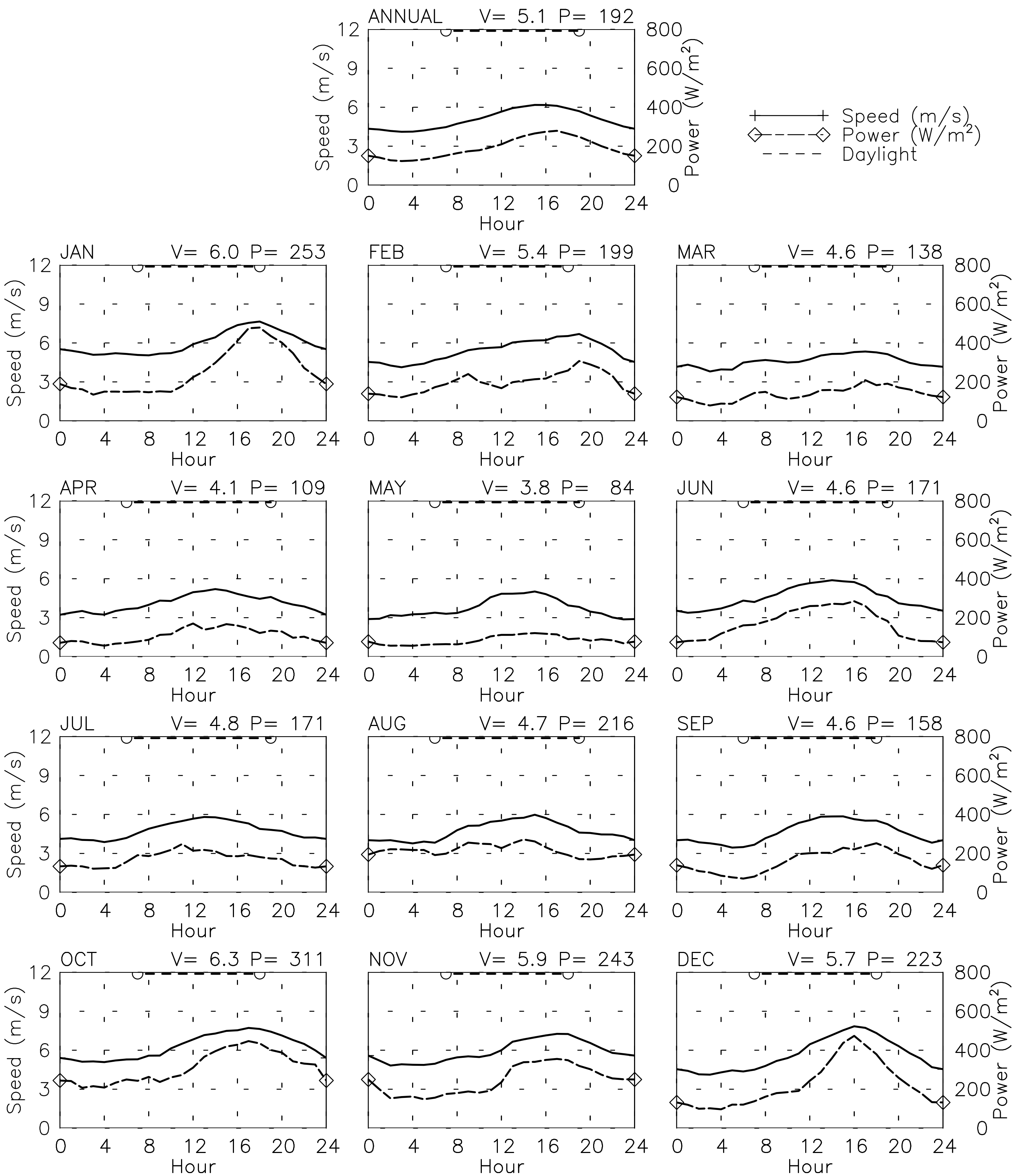
Wed Sep 4 13:59:27 2002

SPEED AND POWER BY HOUR

Changchun 25m – 000081

26° 48' N 120° 05' E – Elev 12m LST=GMT+99 hours *NT= +8

11/98–11/00



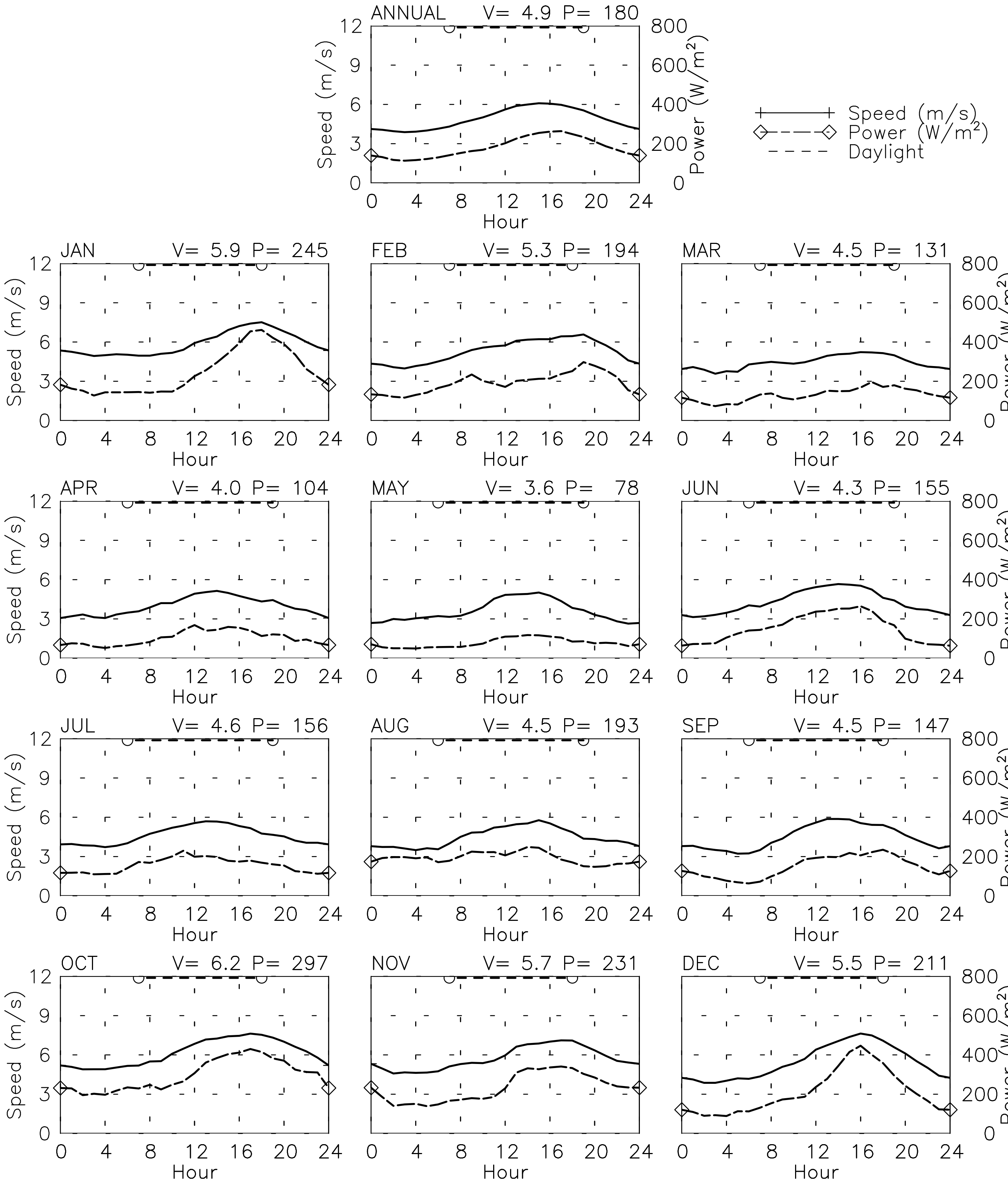
Wed Sep 4 13:59:43 2002

SPEED AND POWER BY HOUR

Changchun 10m – 000082

26° 48' N 120° 05' E – Elev 12m LST=GMT+99 hours *NT= +8

11/98–11/00



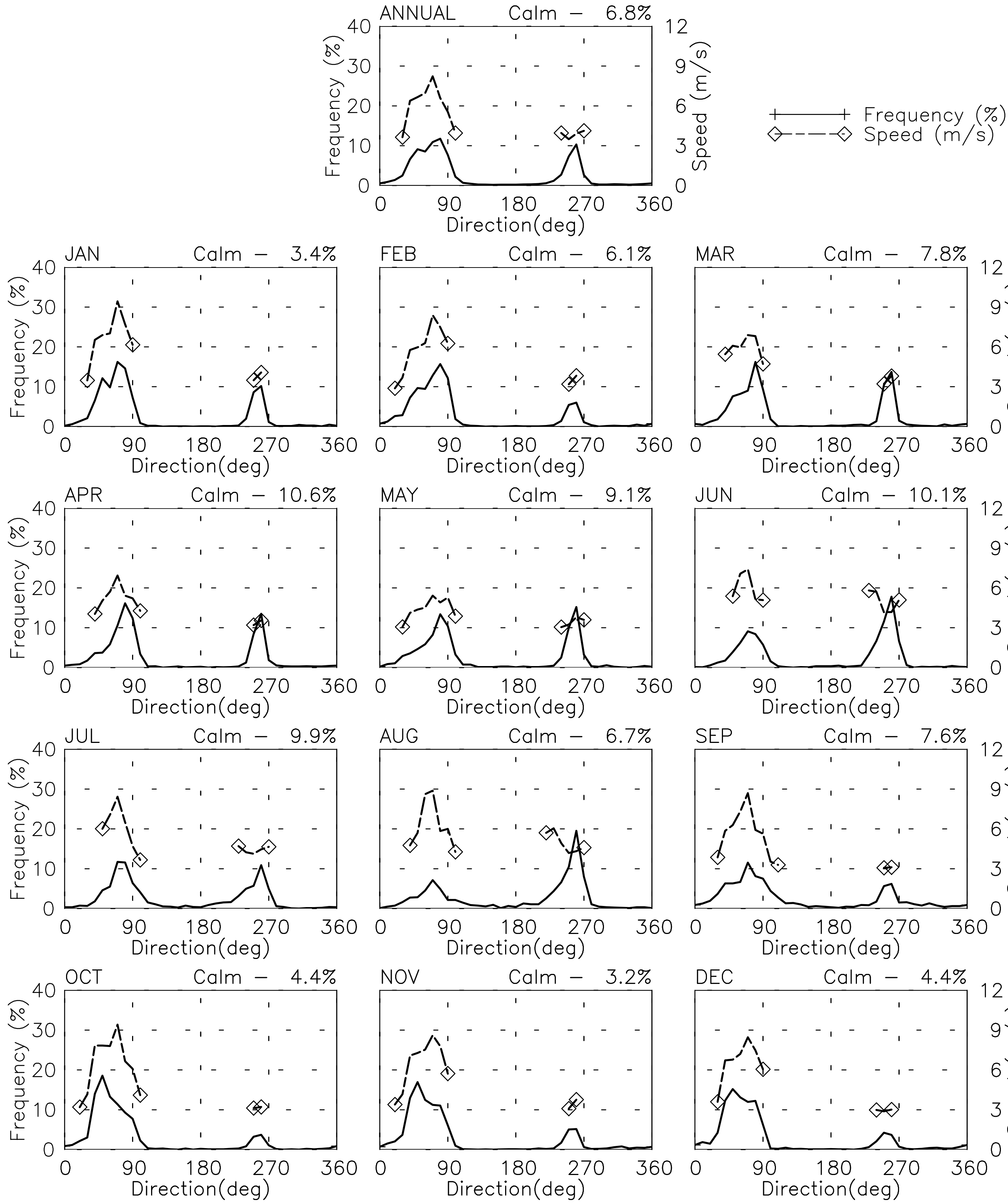
Wed Sep 4 13:59:58 2002

FREQUENCY AND SPEED BY DIRECTION

Changchun 40m – 000080

26° 48' N 120° 05' E – Elev 12m LST=GMT+99 hours *NT= +8

11/98–11/00



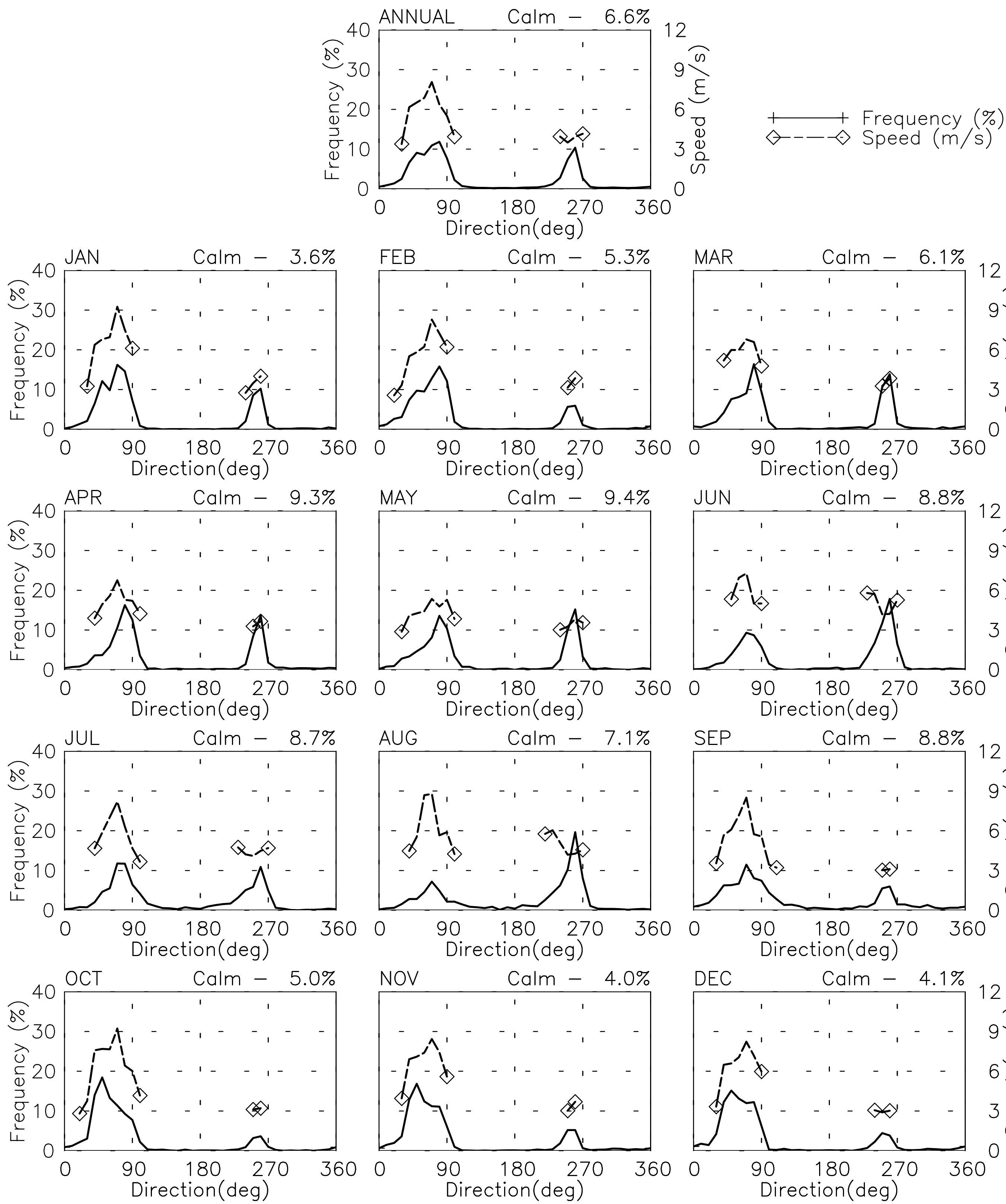
Wed Sep 4 13:59:30 2002

FREQUENCY AND SPEED BY DIRECTION

Changchun 25m – 000081

26° 48' N 120° 05' E – Elev 12m LST=GMT+99 hours *NT= +8

11/98–11/00



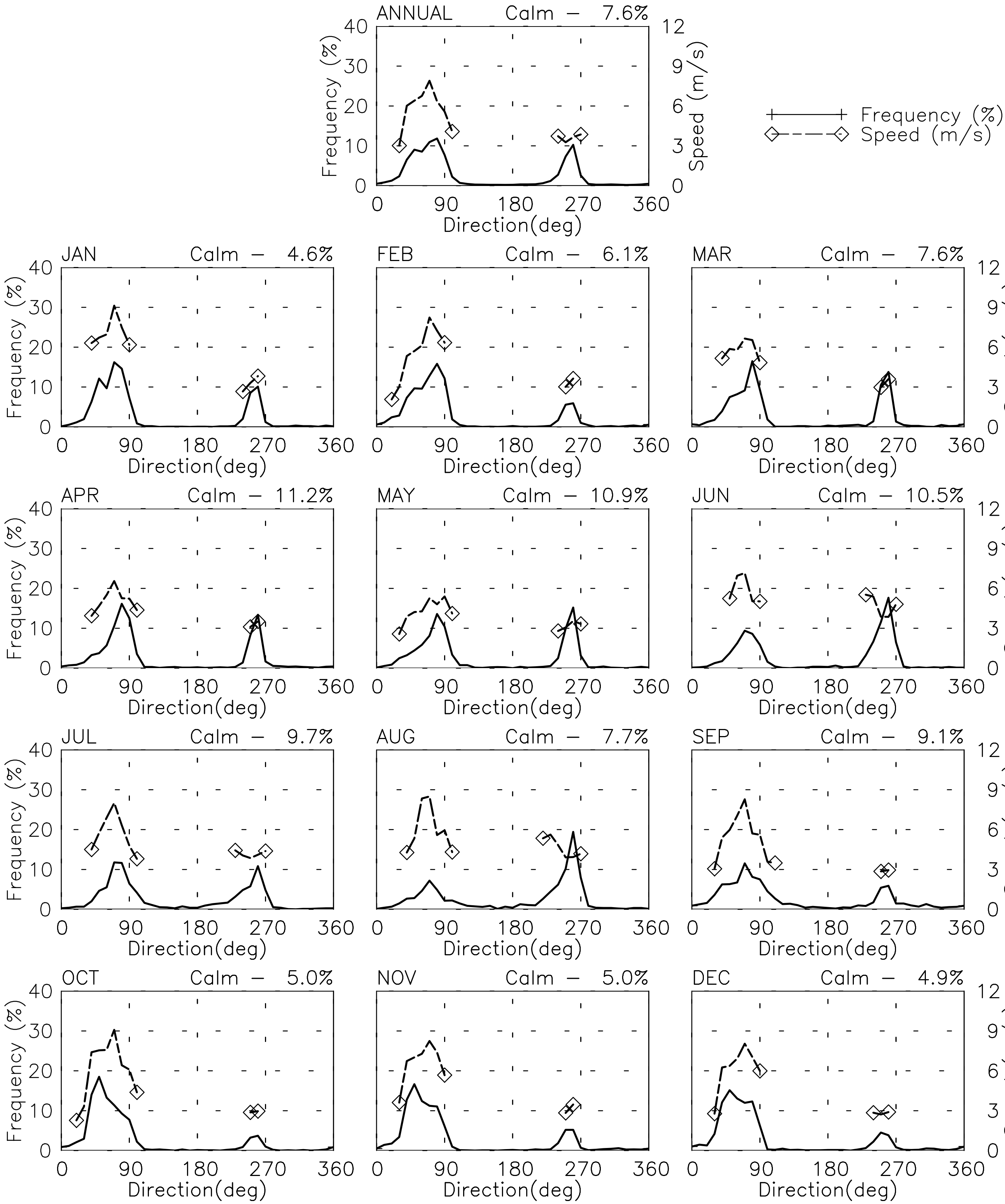
Wed Sep 4 13:59:46 2002

FREQUENCY AND SPEED BY DIRECTION

Changchun 10m – 000082

26° 48' N 120° 05' E – Elev 12m LST=GMT+99 hours *NT= +8

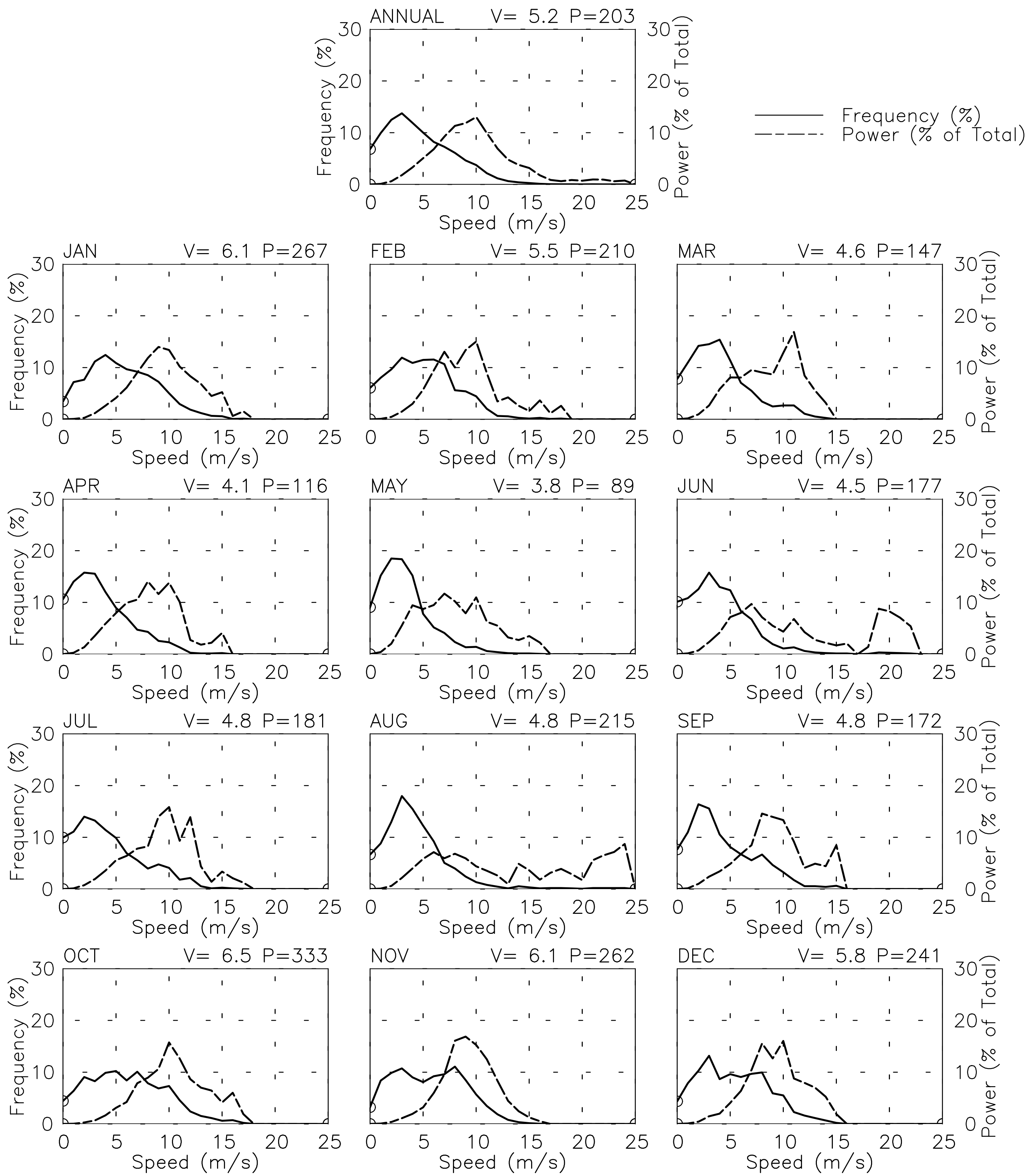
11/98–11/00



Wed Sep 4 14:00:01 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

Changchun 40m – 000080
26° 48' N 120° 05' E – Elev 12m LST=GMT+99 hours *NT= +8
11/98–11/00



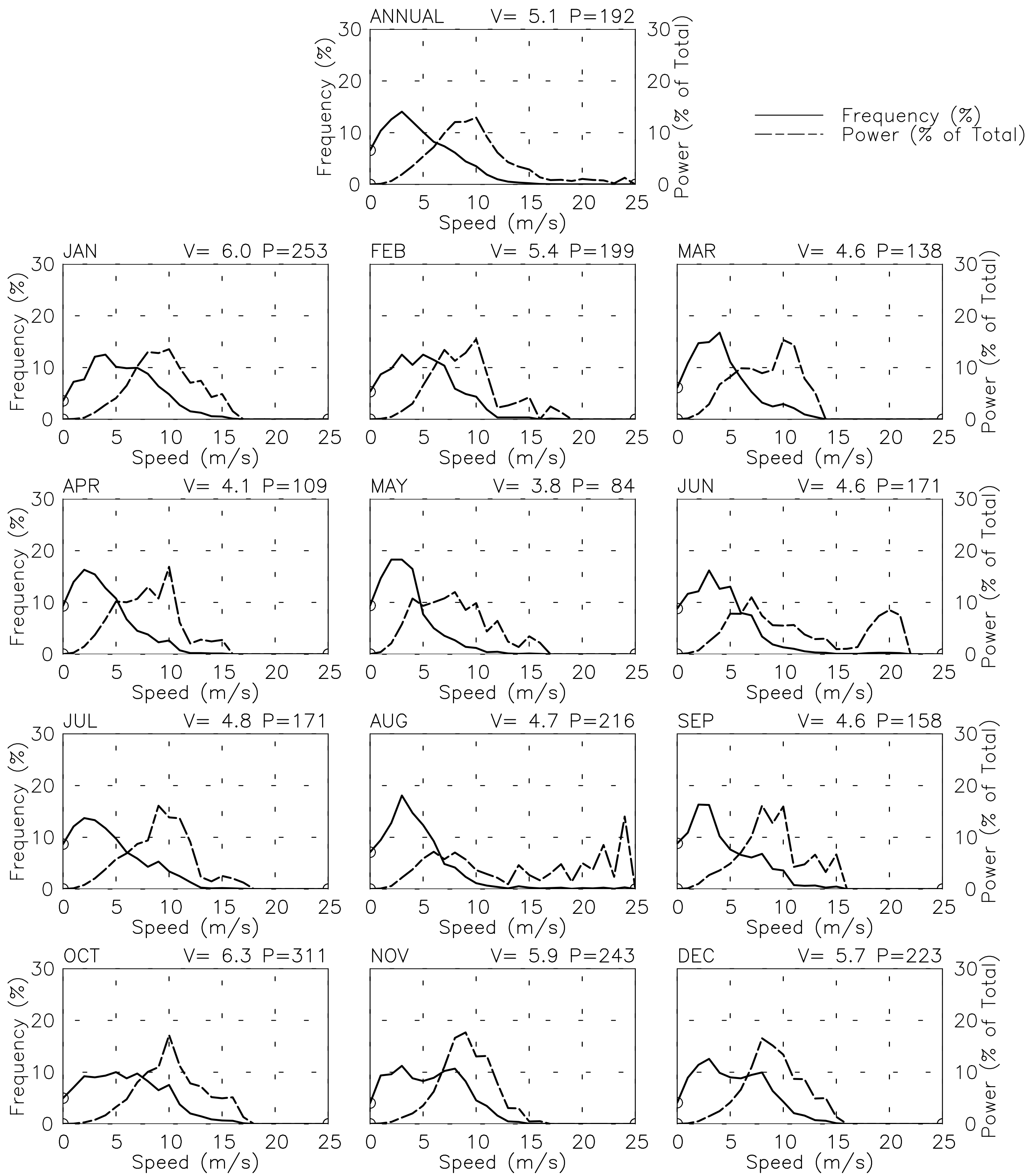
Wed Sep 4 13:59:34 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

Changchun 25m – 000081

26° 48' N 120° 05' E – Elev 12m LST=GMT+99 hours *NT= +8

11/98–11/00



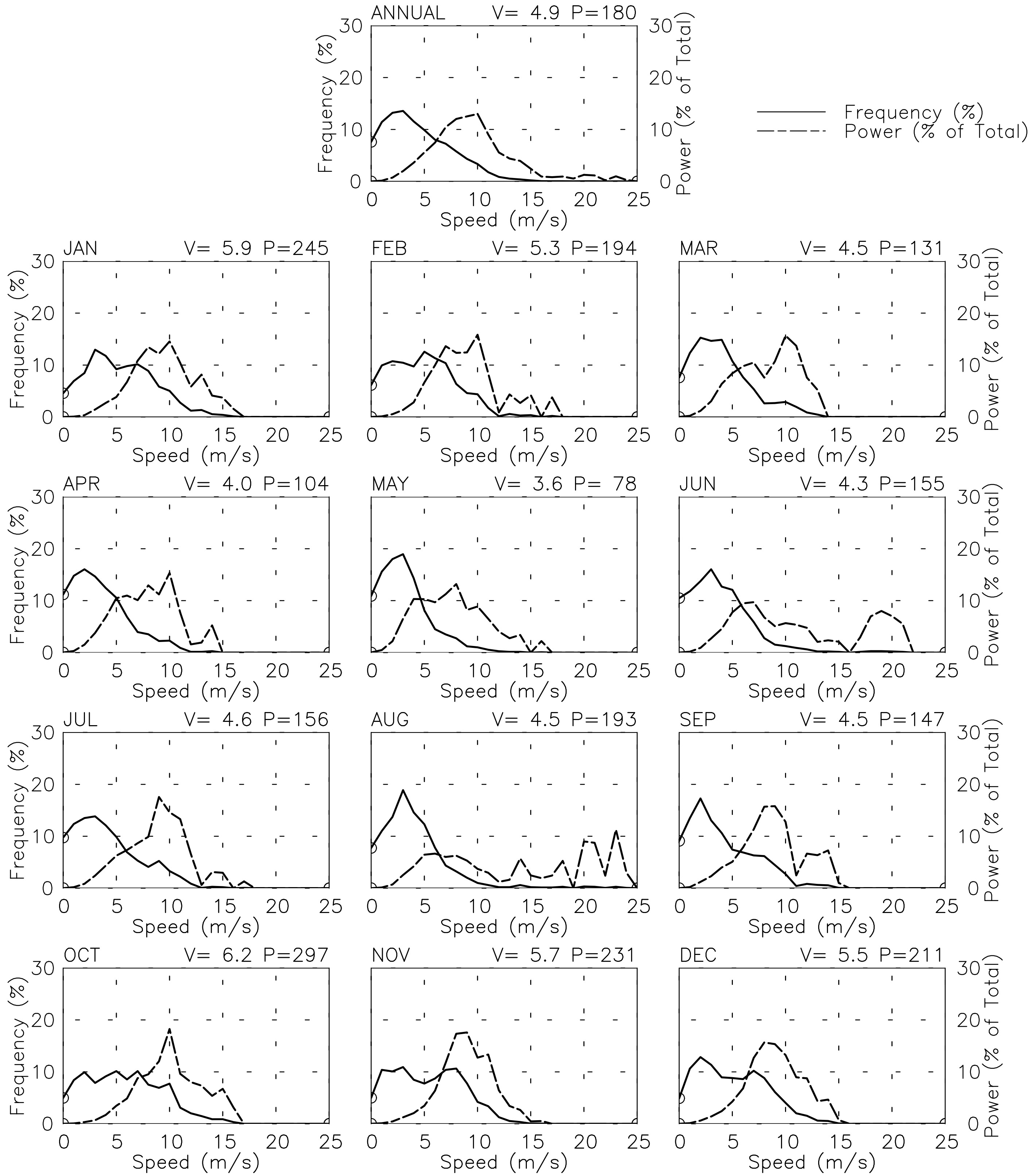
Wed Sep 4 13:59:49 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

Changchun 10m - 000082

26° 48' N 120° 05' E - Elev 12m LST=GMT+99 hours *NT= +8

11/98-11/00



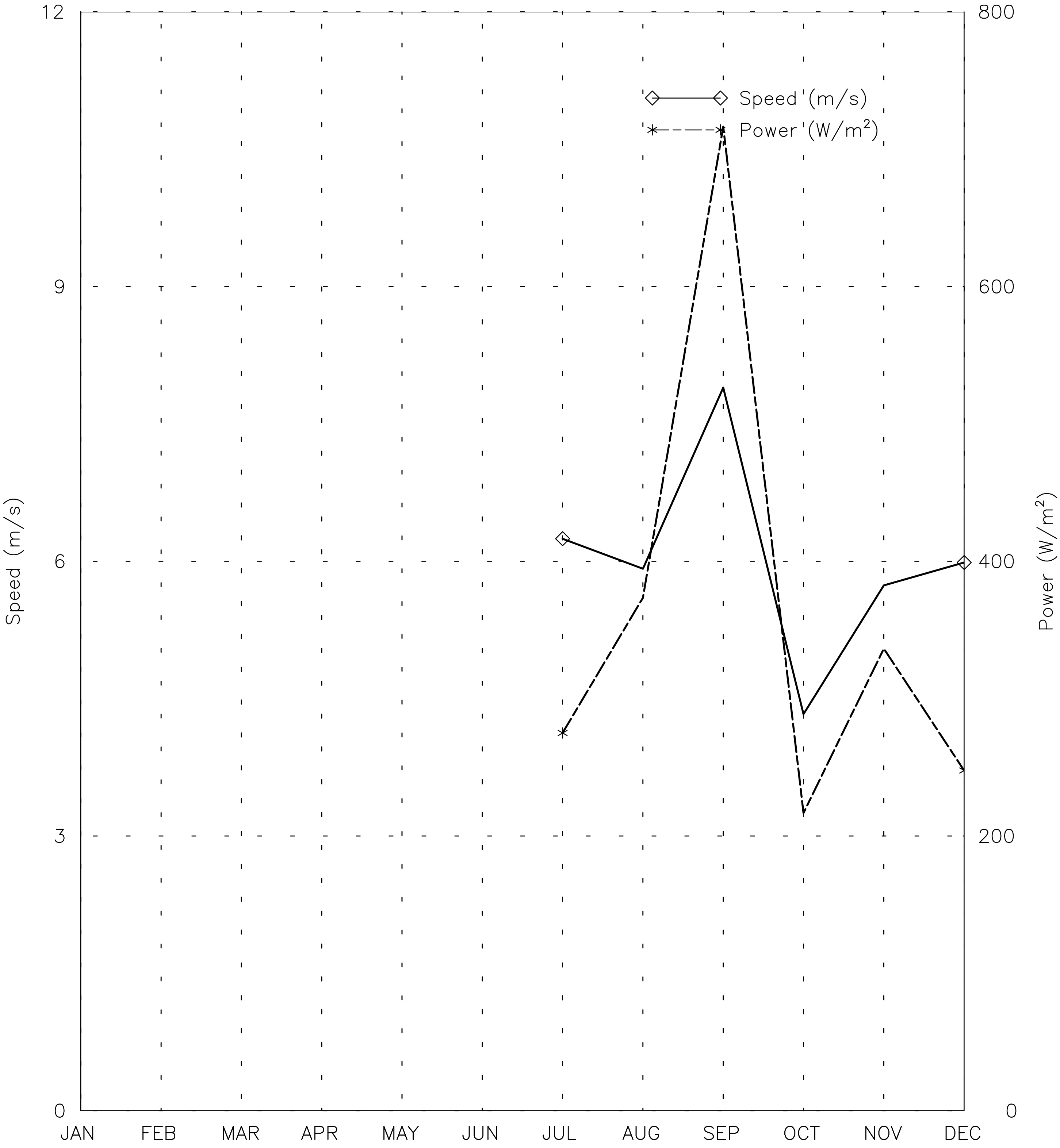
Wed Sep 4 14:00:04 2002

SPEED AND POWER BY MONTH

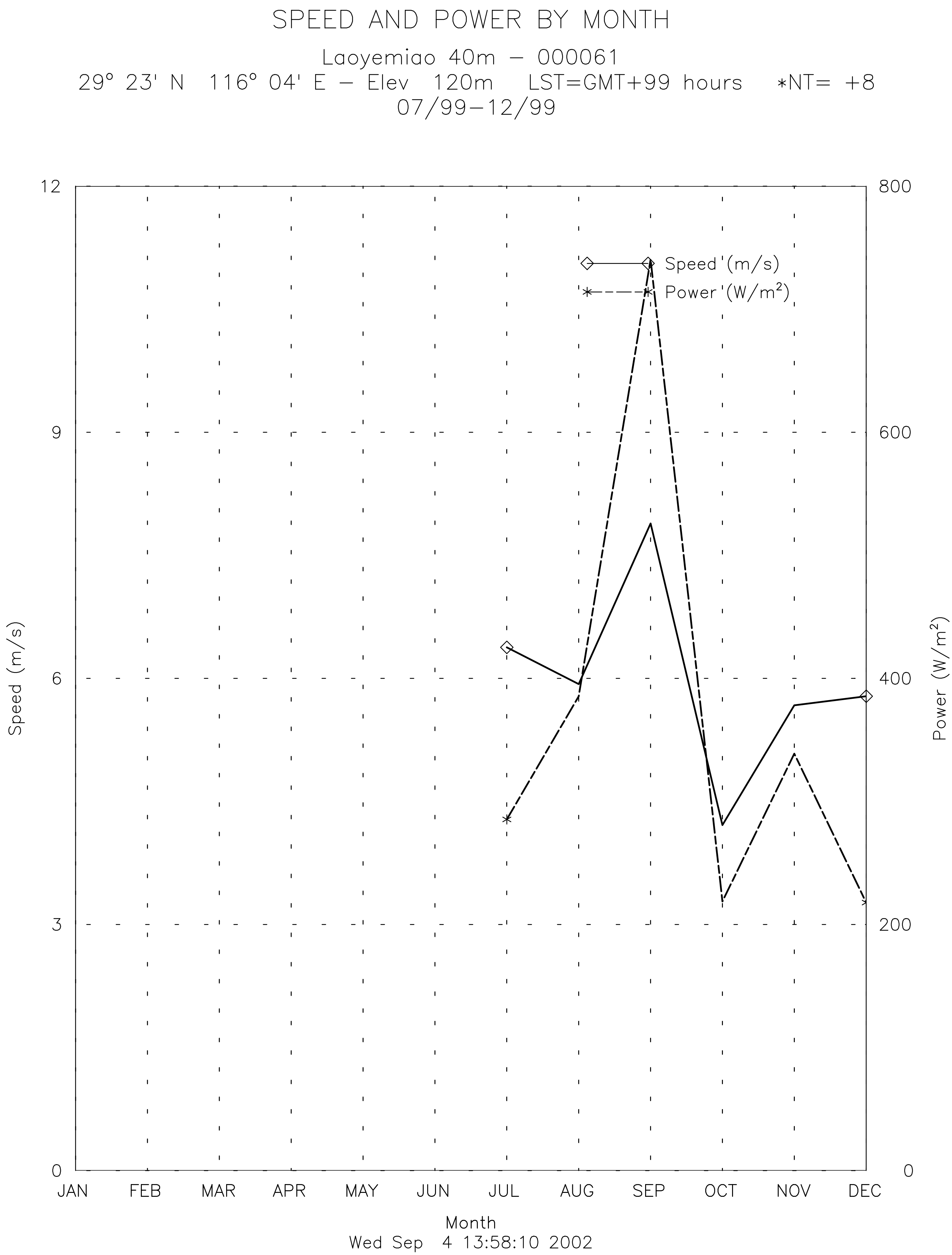
Laoyemiao 50m - 000060

29° 23' N 116° 04' E - Elev 120m LST=GMT+99 hours *NT= +8

07/99-12/99



Wed Sep 4 13:57:58 2002

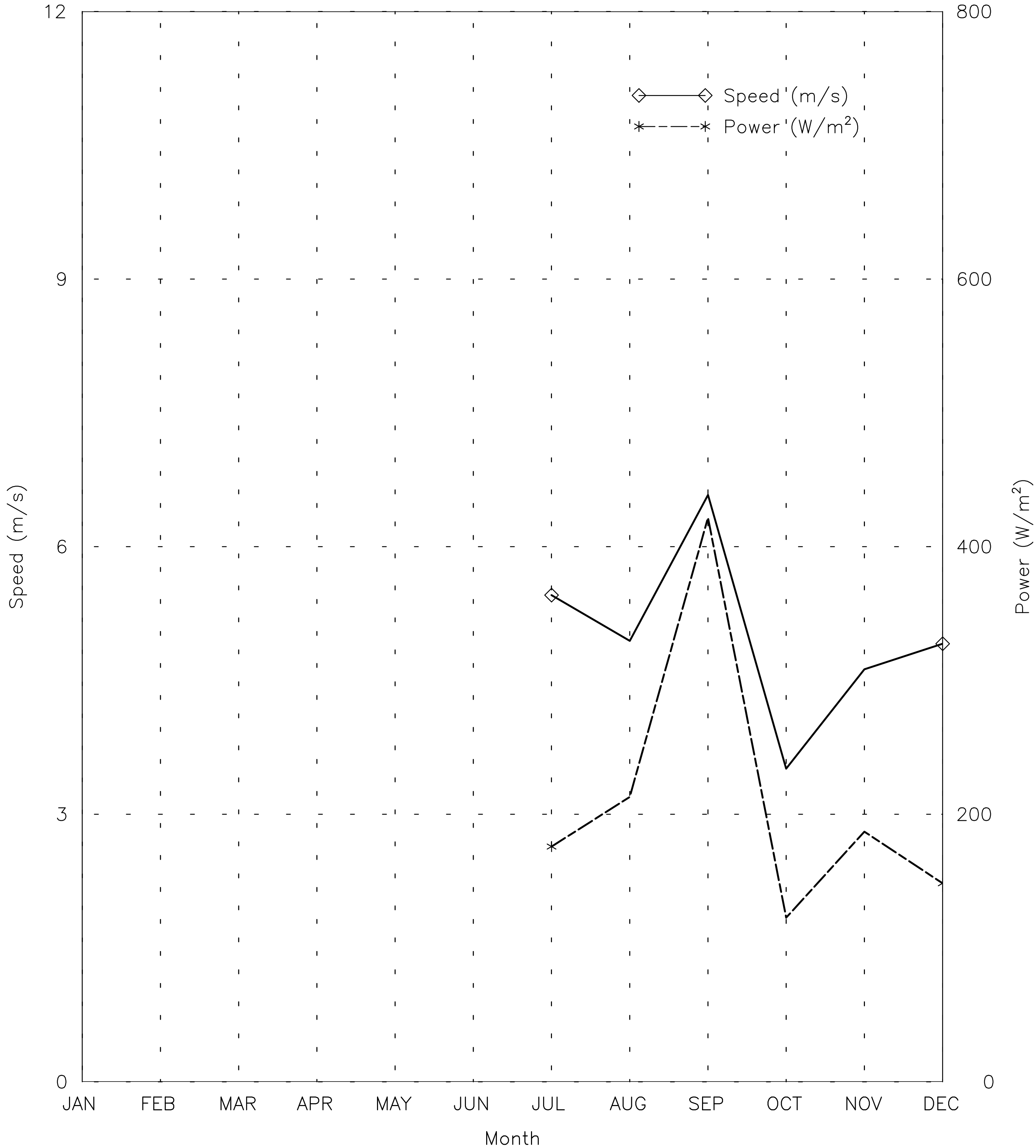

SPEED AND POWER BY MONTH
Laoyemiao 40m - 000061
29° 23' N 116° 04' E - Elev 120m LST=GMT+99 hours *NT= +8
07/99-12/99
Speed (m/s)
Power (W/m²)
12
9
6
3
0
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:58:10 2002

SPEED AND POWER BY MONTH

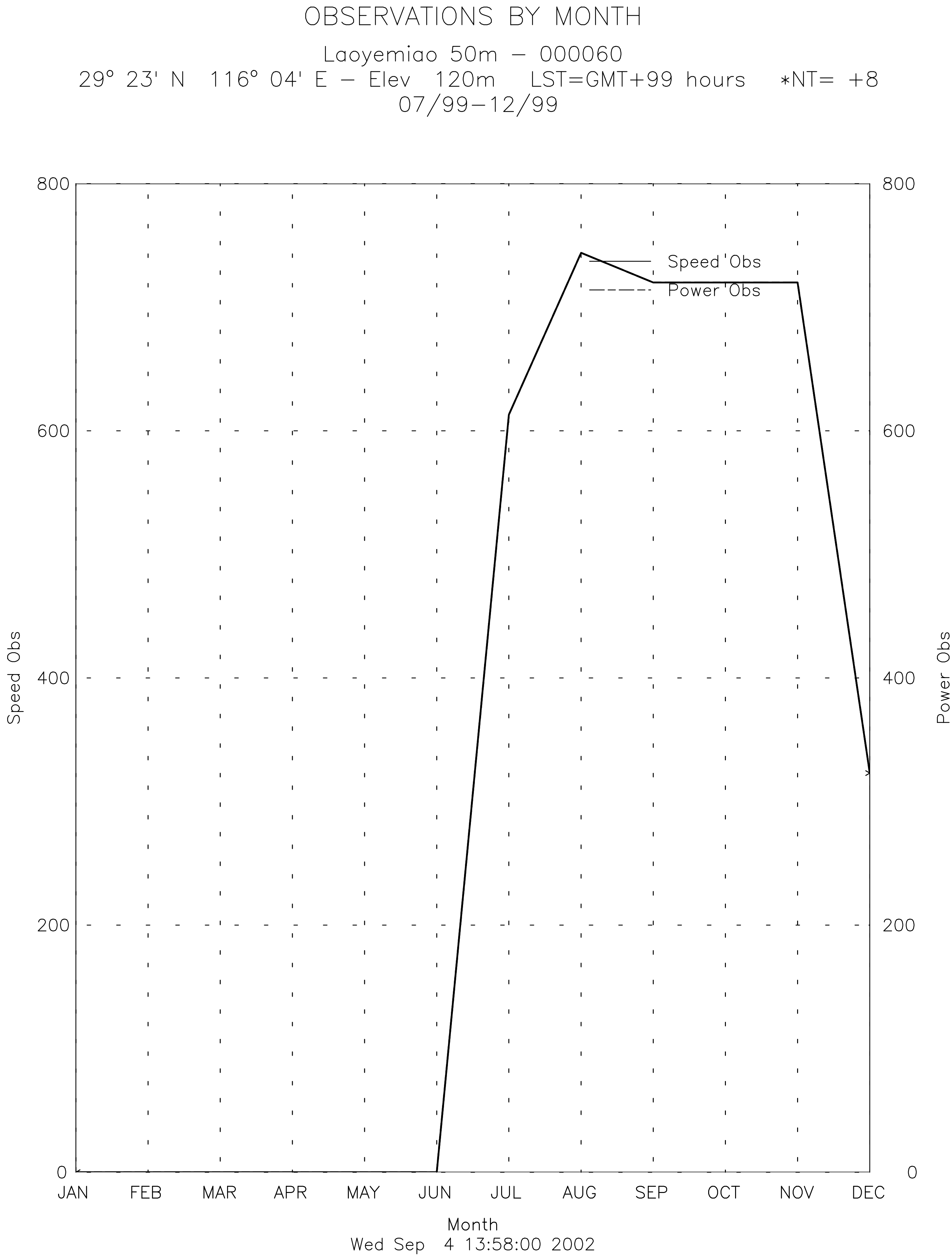
Laoyemiao 10m - 000062

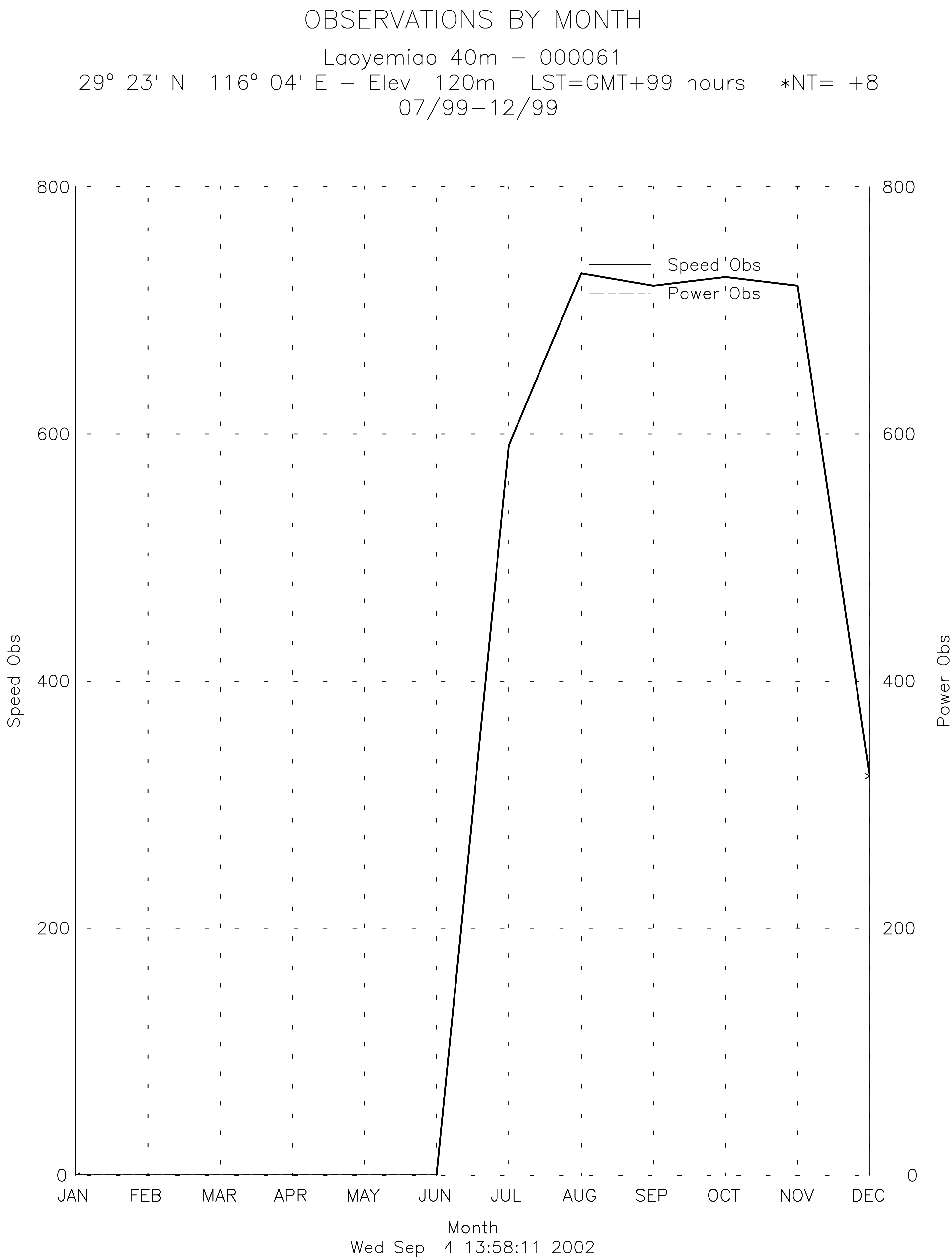
29° 23' N 116° 04' E - Elev 120m LST=GMT+99 hours *NT= +8

07/99-12/99



Wed Sep 4 13:58:22 2002


OBSERVATIONS BY MONTH
Laoyemiao 50m - 000060
29° 23' N 116° 04' E - Elev 120m LST=GMT+99 hours *NT= +8
07/99-12/99
Speed'Obs
Power'Obs
800
600
400
200
0
Speed Obs
Power Obs
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:58:00 2002

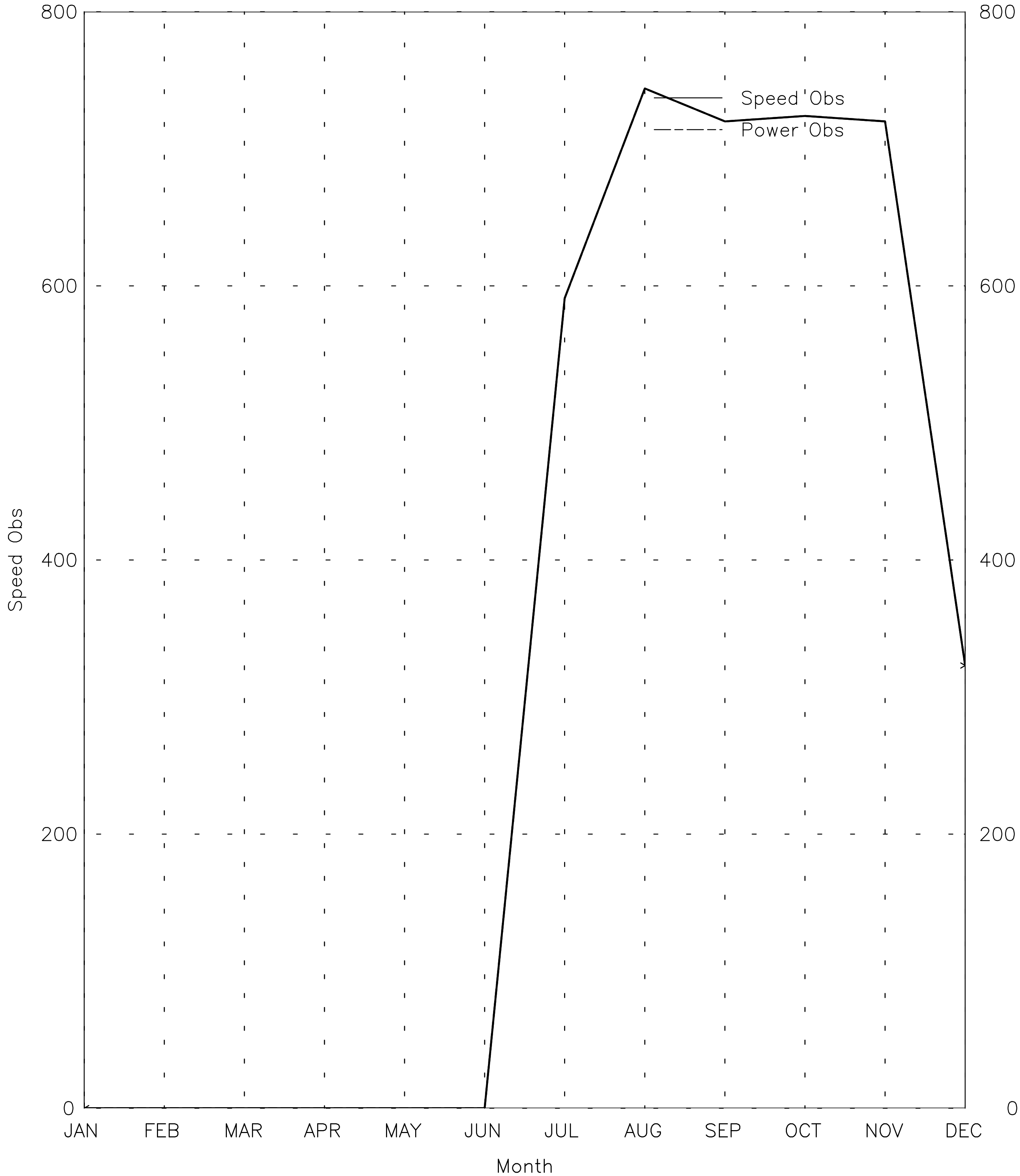

OBSERVATIONS BY MONTH
Laoyemiao 40m - 000061
29° 23' N 116° 04' E - Elev 120m LST=GMT+99 hours *NT= +8
07/99-12/99
Speed Obs
Power Obs
Speed'Obs
Power'Obs
0
200
400
600
800
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:58:11 2002

OBSERVATIONS BY MONTH

Laoyemiao 10m - 000062

29° 23' N 116° 04' E - Elev 120m LST=GMT+99 hours *NT= +8

07/99-12/99



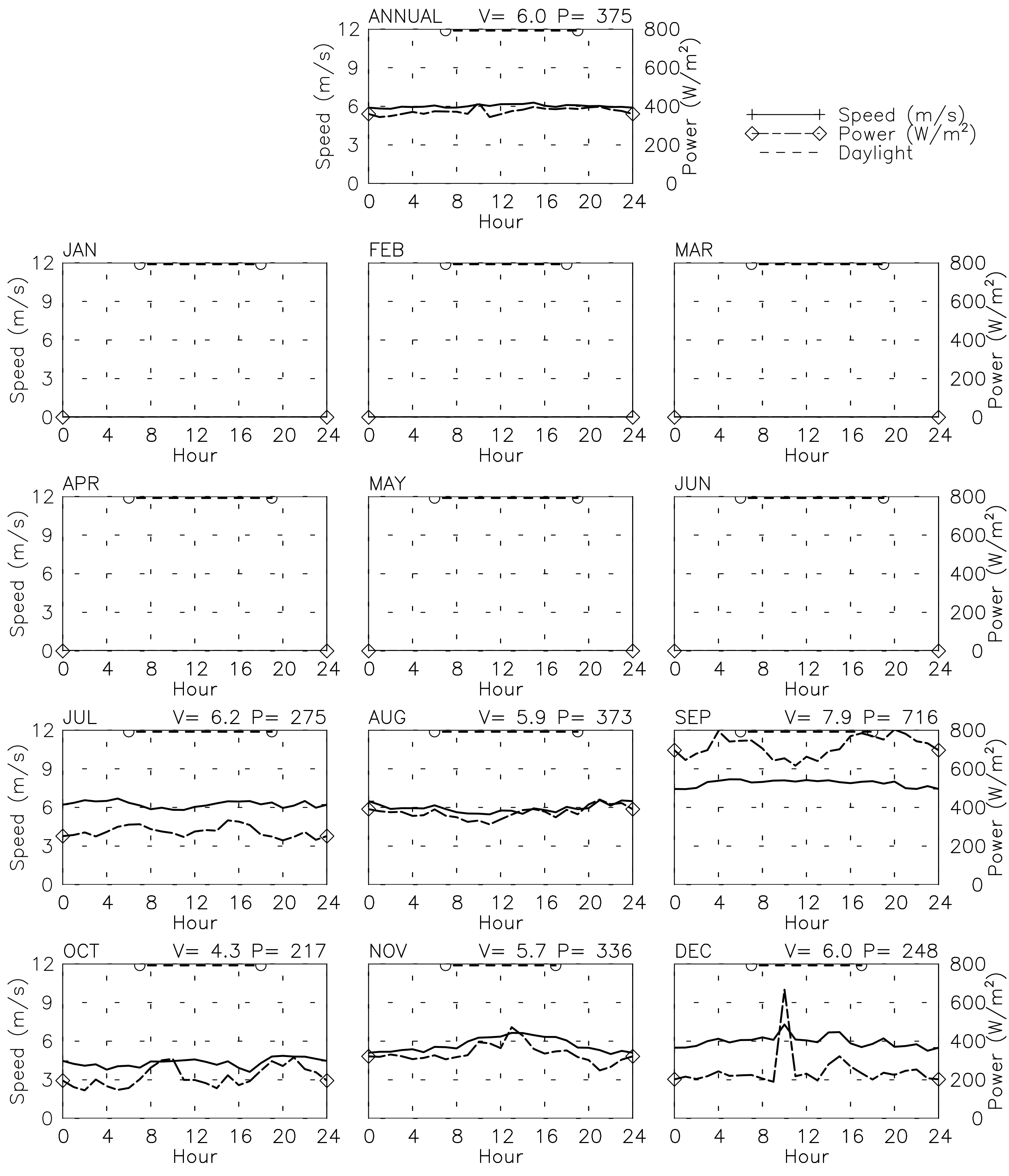
Wed Sep 4 13:58:23 2002

SPEED AND POWER BY HOUR

Laoyemiao 50m – 000060

29° 23' N 116° 04' E – Elev 120m LST=GMT+99 hours *NT= +8

07/99–12/99



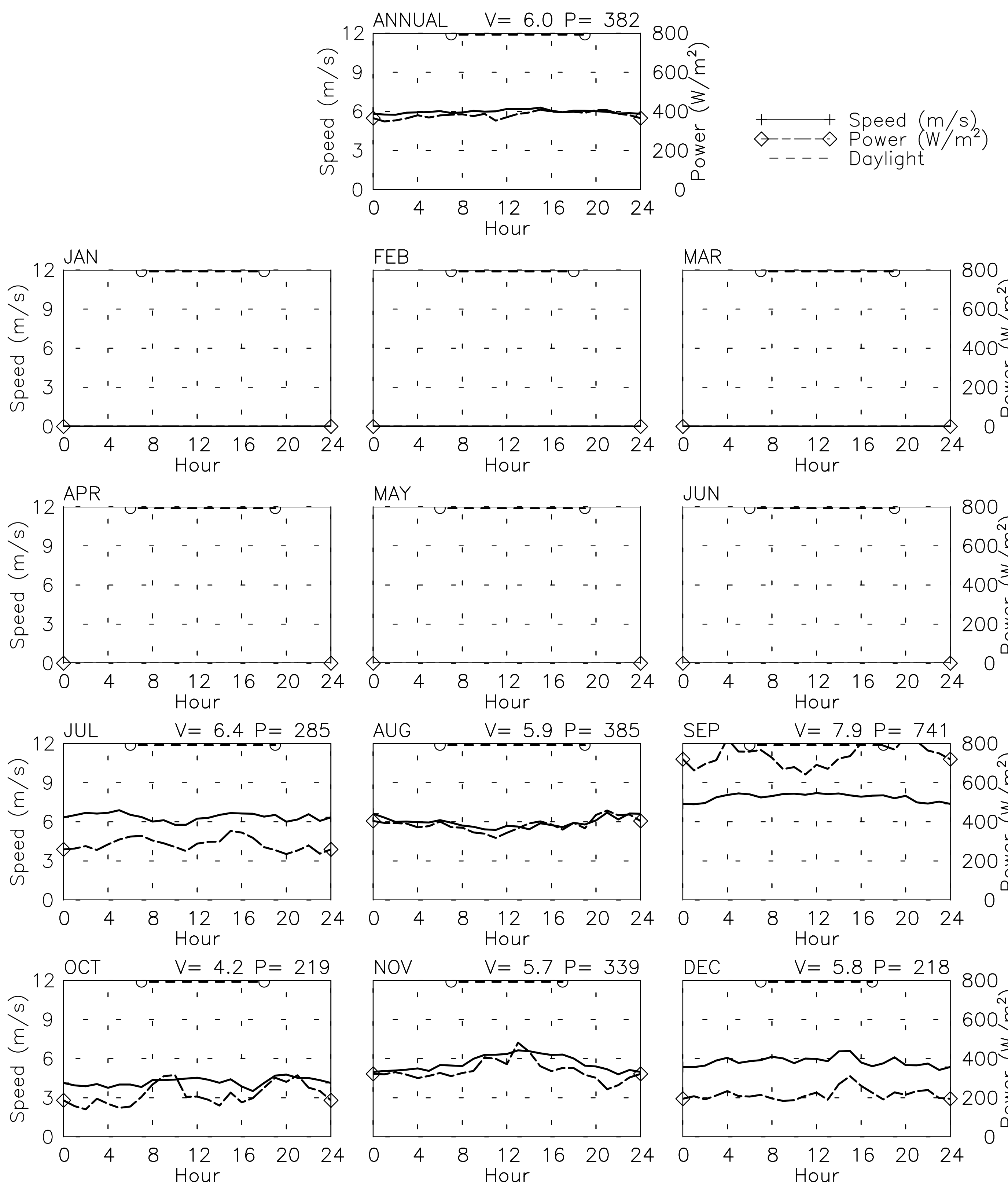
Wed Sep 4 13:58:01 2002

SPEED AND POWER BY HOUR

Laoyemiao 40m − 000061

29° 23' N 116° 04' E − Elev 120m LST=GMT+99 hours *NT= +8

07/99−12/99



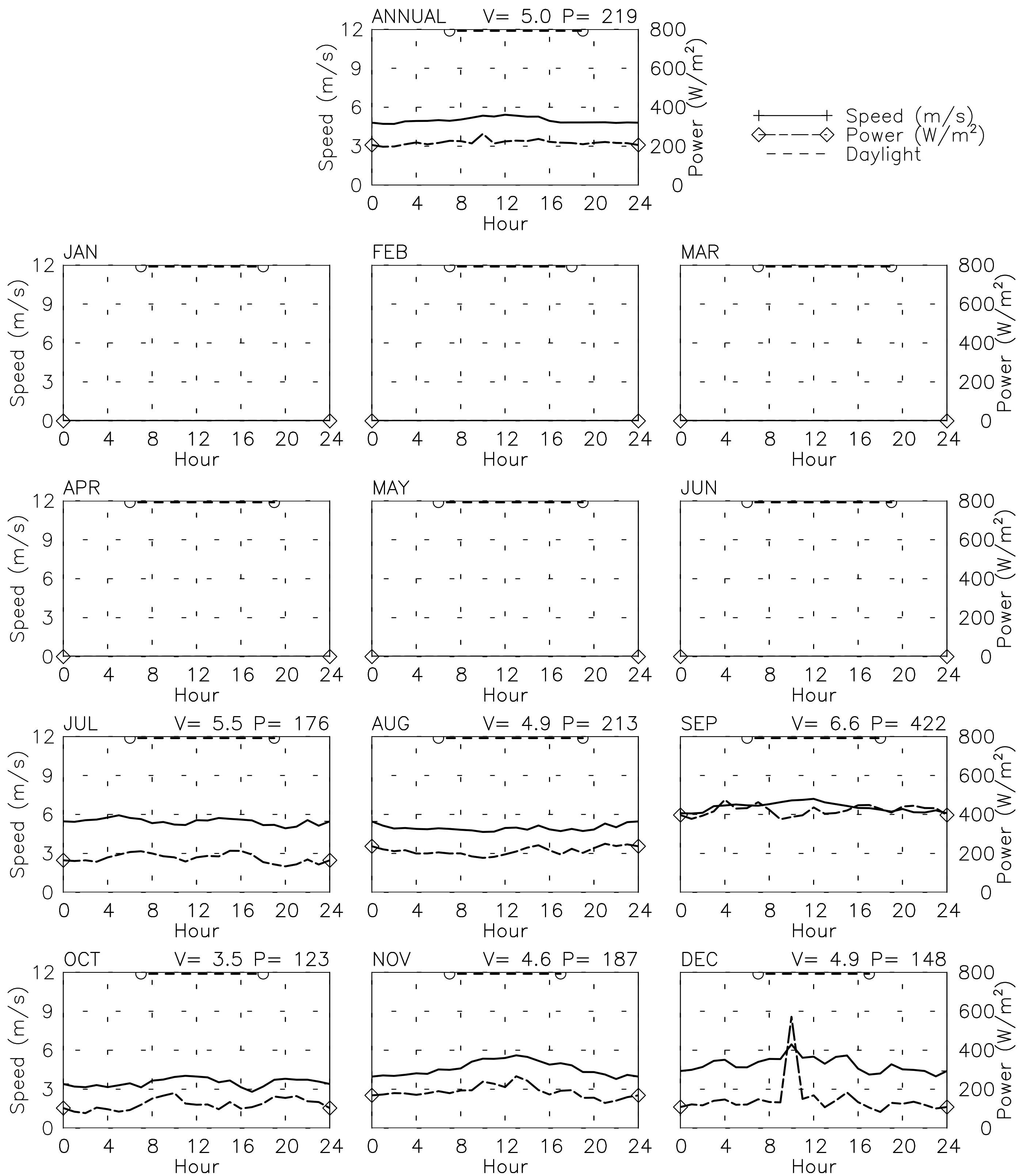
Wed Sep 4 13:58:13 2002

SPEED AND POWER BY HOUR

Laoyemiao 10m – 000062

29° 23' N 116° 04' E – Elev 120m LST=GMT+99 hours *NT= +8

07/99–12/99



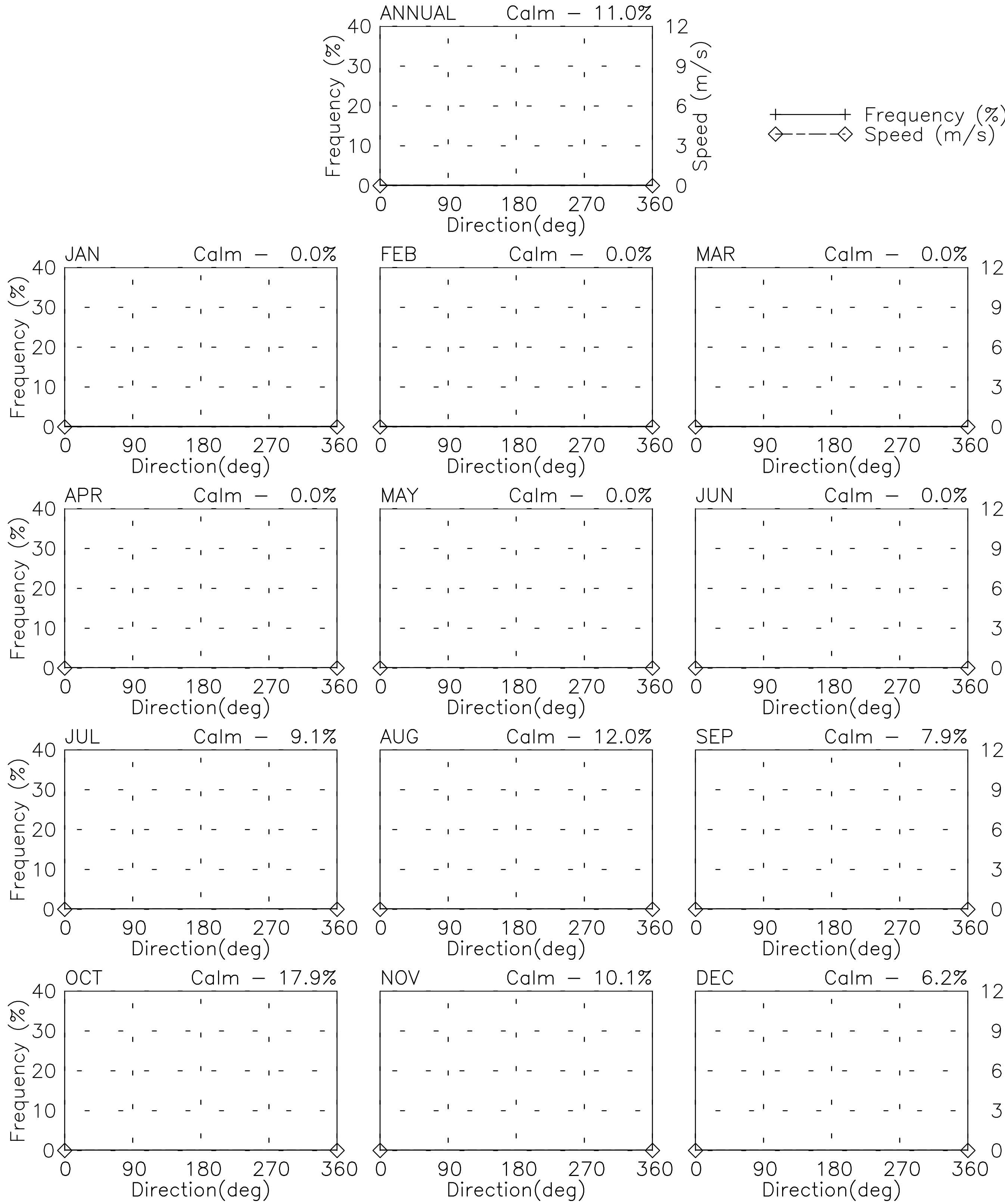
Wed Sep 4 13:58:24 2002

FREQUENCY AND SPEED BY DIRECTION

Laoyemiao 50m – 000060

29° 23' N 116° 04' E – Elev 120m LST=GMT+99 hours *NT= +8

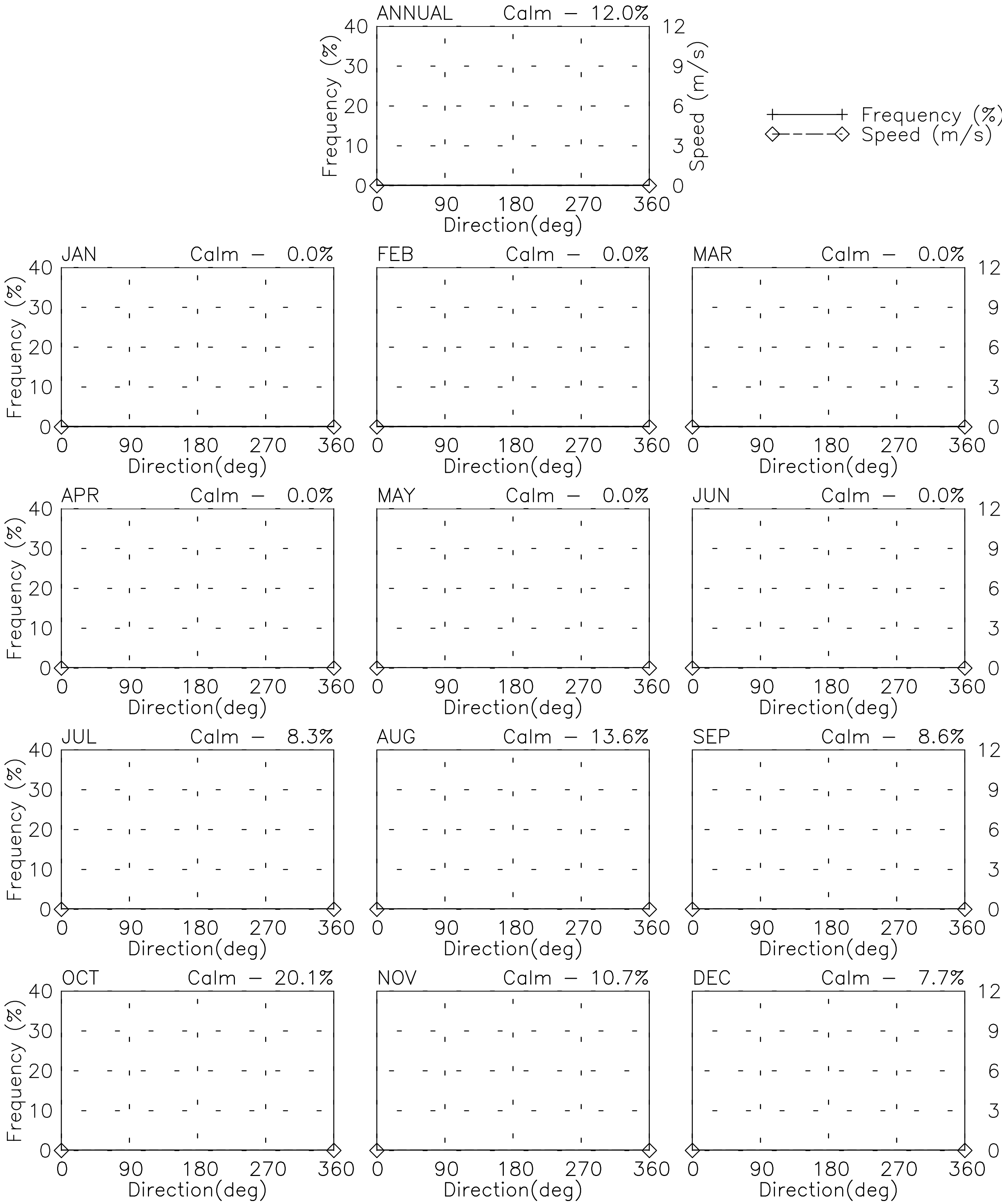
07/99–12/99



Wed Sep 4 13:58:04 2002

FREQUENCY AND SPEED BY DIRECTION

Laoyemiao 40m - 000061
29° 23' N 116° 04' E - Elev 120m LST=GMT+99 hours *NT= +8
07/99-12/99



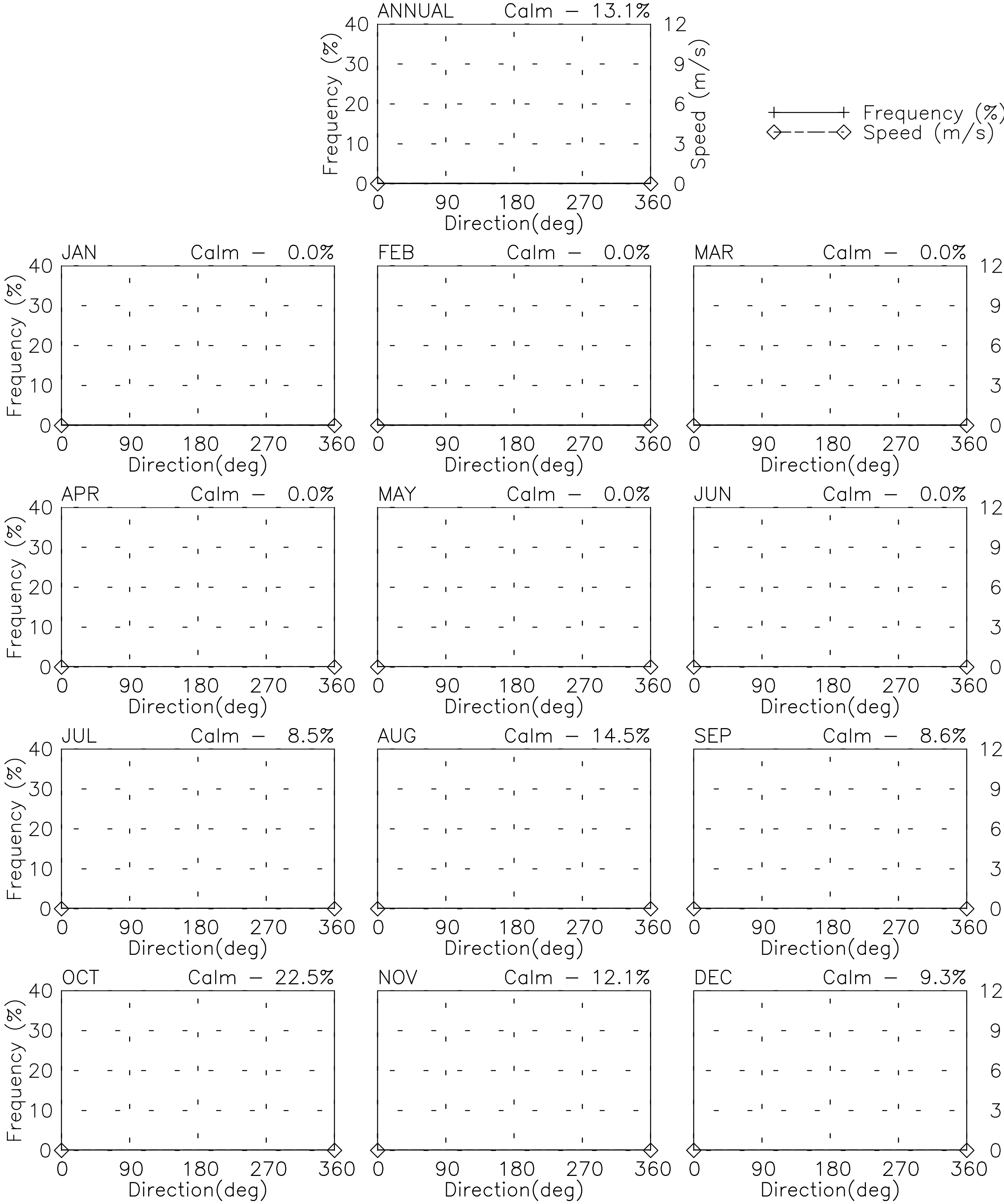
Wed Sep 4 13:58:15 2002

FREQUENCY AND SPEED BY DIRECTION

Laoyemiao 10m – 000062

29° 23' N 116° 04' E – Elev 120m LST=GMT+99 hours *NT= +8

07/99–12/99



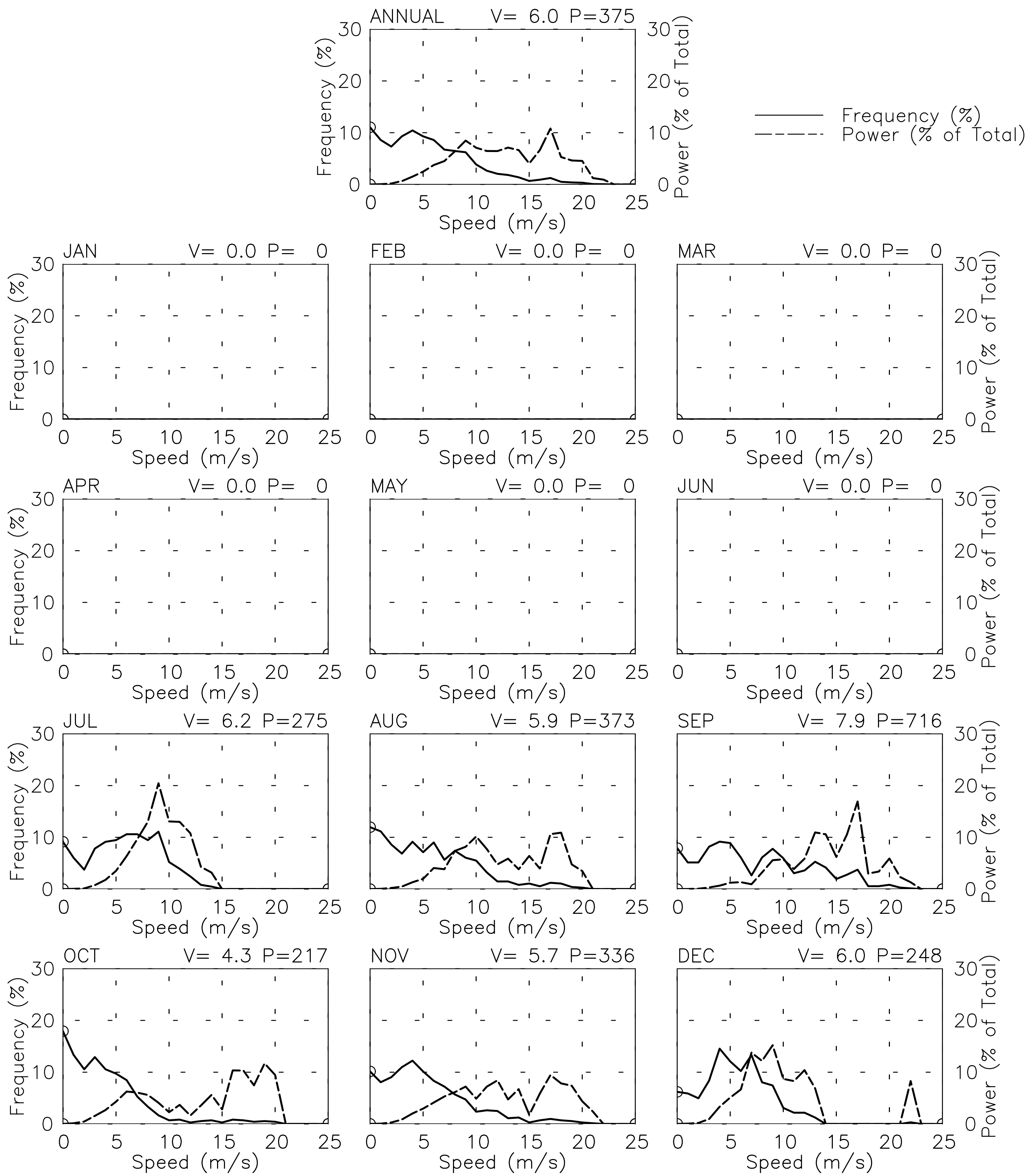
Wed Sep 4 13:58:27 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

Laoyemiao 50m – 000060

29° 23' N 116° 04' E – Elev 120m LST=GMT+99 hours *NT= +8

07/99–12/99



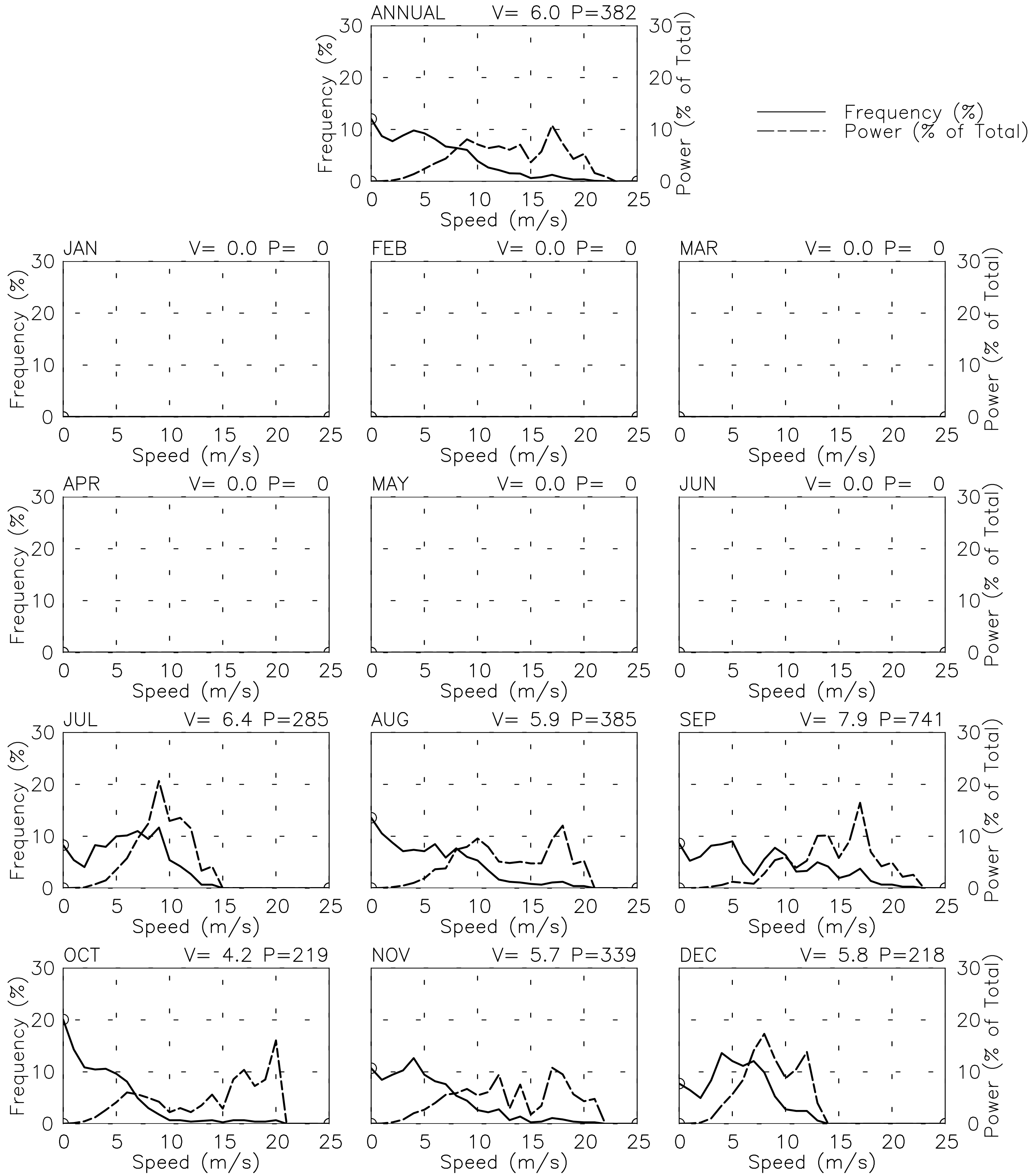
Wed Sep 4 13:58:06 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

Laoyemiao 40m - 000061

29° 23' N 116° 04' E - Elev 120m LST=GMT+99 hours *NT= +8

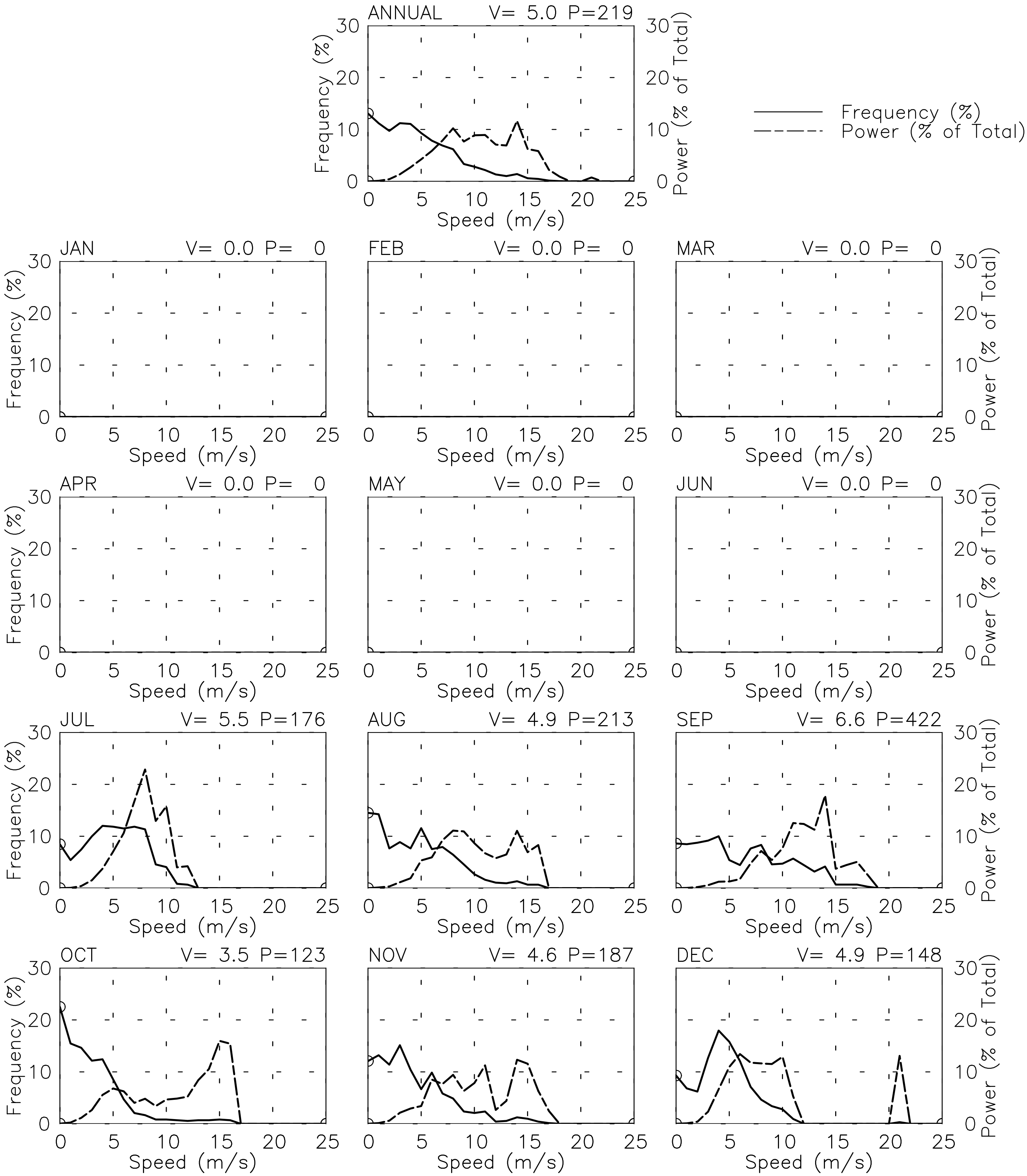
07/99-12/99



Wed Sep 4 13:58:18 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

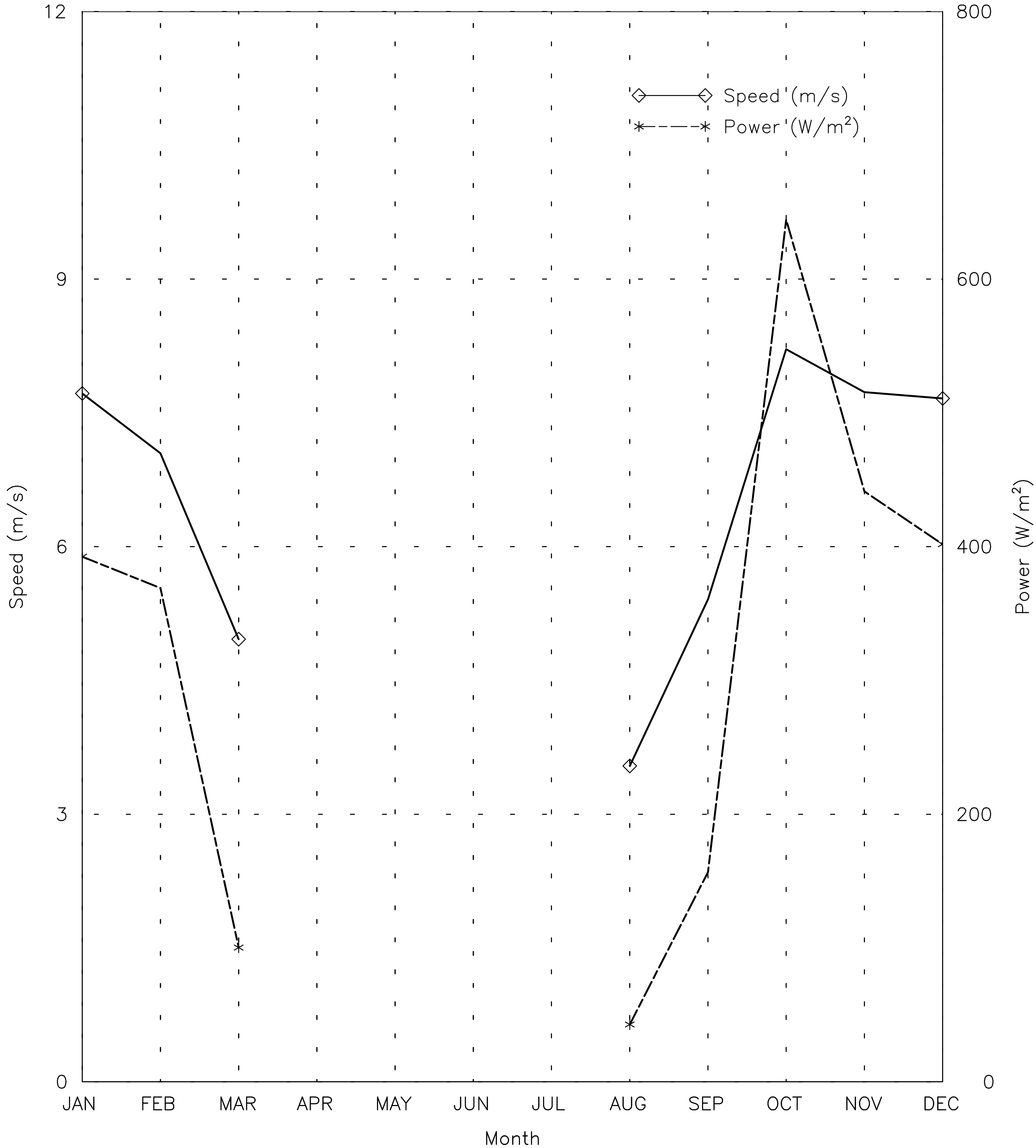
Laoyemiao 10m – 000062
29° 23' N 116° 04' E – Elev 120m LST=GMT+99 hours *NT= +8
07/99–12/99



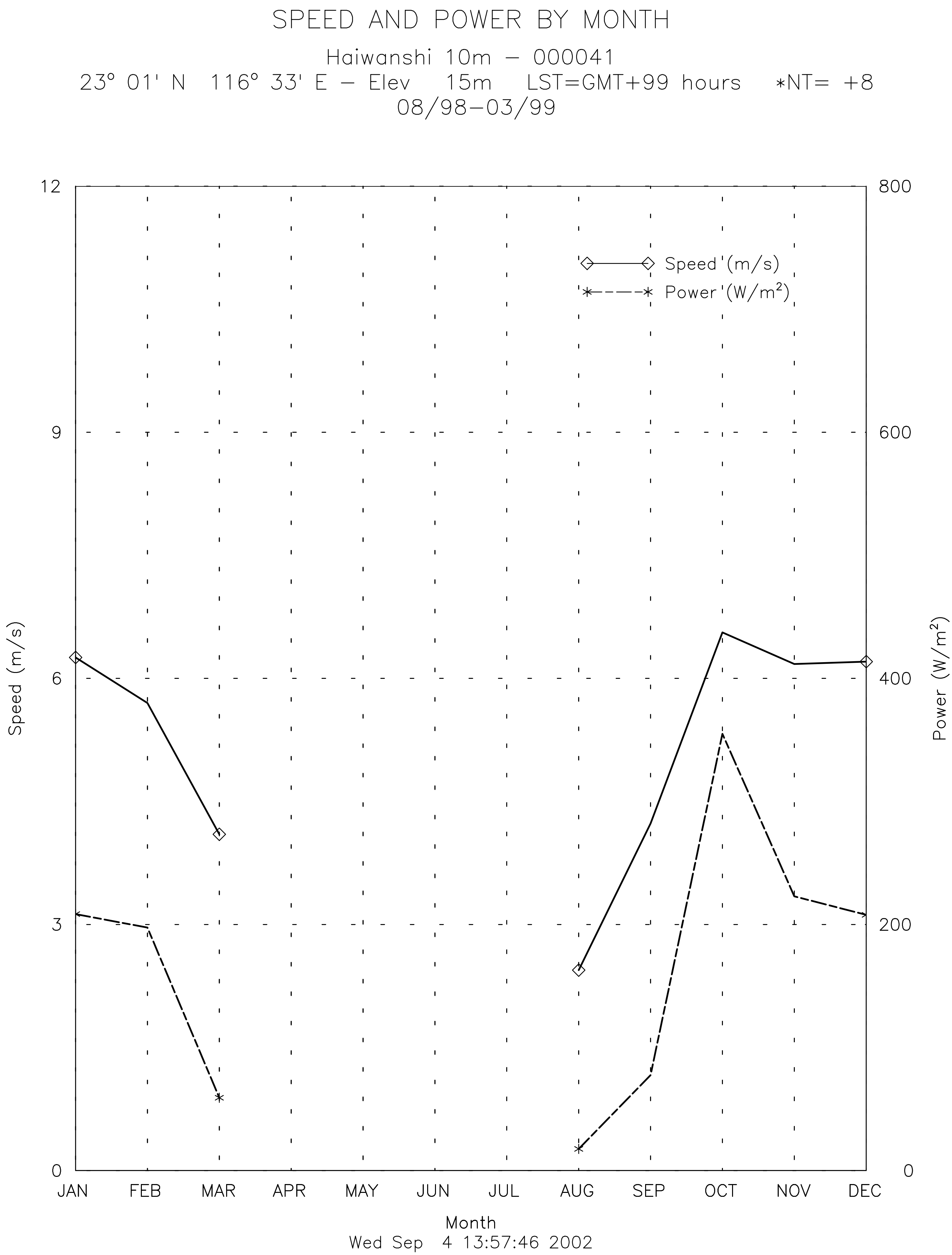
Wed Sep 4 13:58:29 2002

SPEED AND POWER BY MONTH

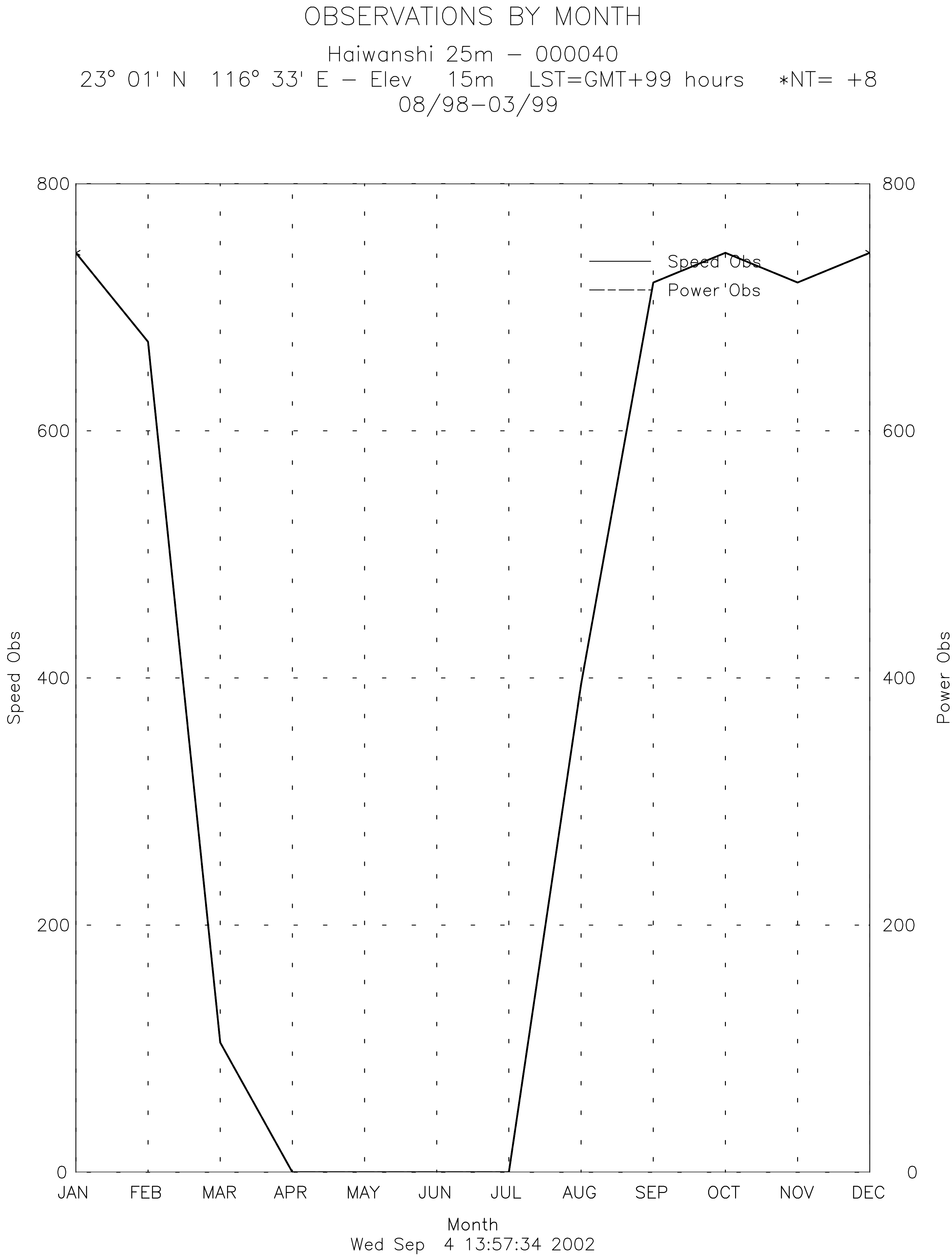
Haiwanshi 25m - 000040
23° 01' N 116° 33' E - Elev 15m LST=GMT+99 hours *NT= +8
08/98-03/99

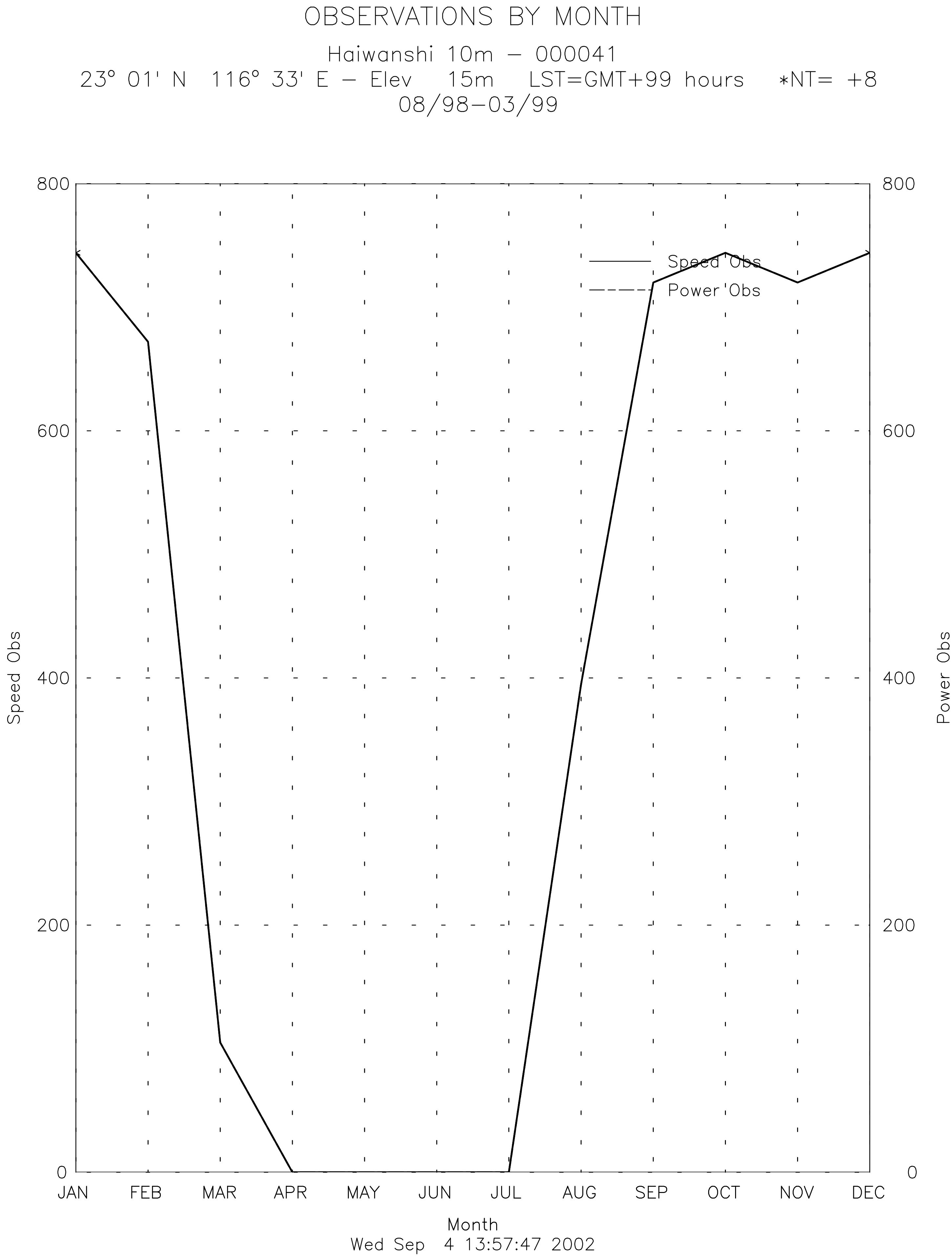


Wed Sep 4 13:57:33 2002



SPEED AND POWER BY MONTH
Haiwanshi 10m - 000041
23° 01' N 116° 33' E - Elev 15m LST=GMT+99 hours *NT= +8
08/98-03/99
Speed (m/s)
Power (W/m²)
12
9
6
3
0
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:57:46 2002


OBSERVATIONS BY MONTH
Haiwanshi 25m - 000040
23° 01' N 116° 33' E - Elev 15m LST=GMT+99 hours *NT= +8
08/98-03/99
Speed Obs
Power Obs
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:57:34 2002



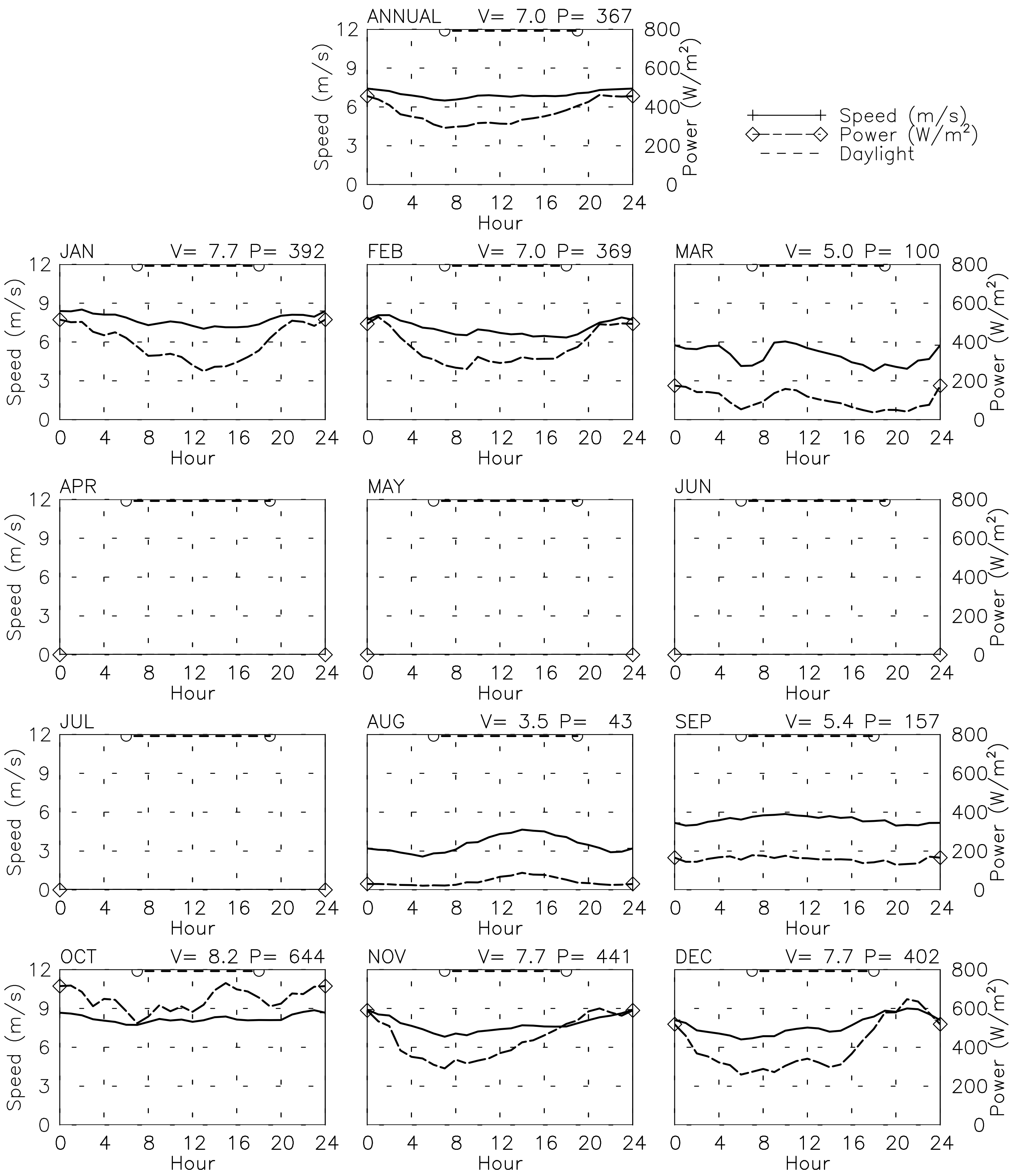
OBSERVATIONS BY MONTH
Haiwanshi 10m - 000041
23° 01' N 116° 33' E - Elev 15m LST=GMT+99 hours *NT= +8
08/98-03/99
Speed Obs
Power Obs
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:57:47 2002

SPEED AND POWER BY HOUR

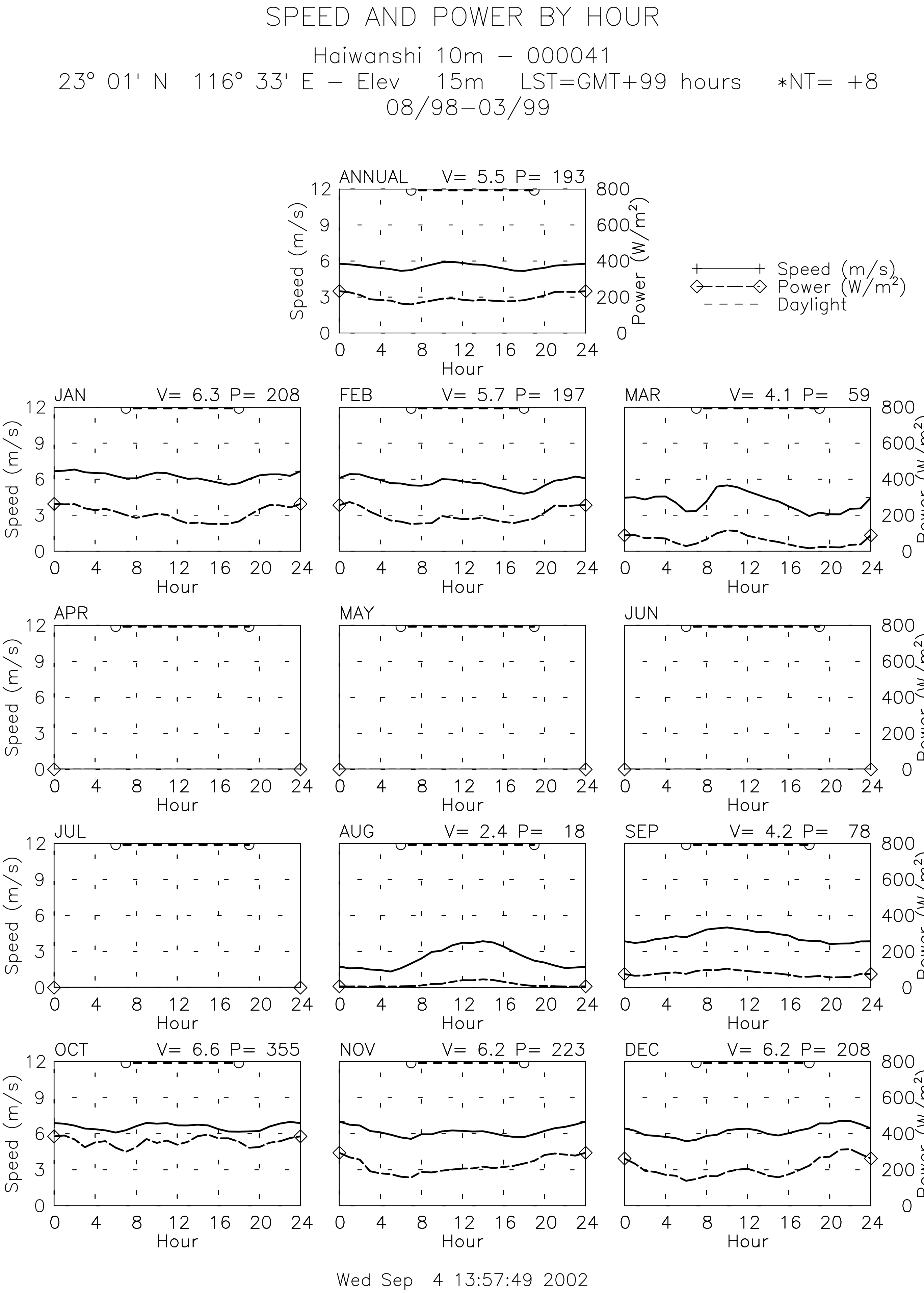
Haiwanshi 25m - 000040

23° 01' N 116° 33' E - Elev 15m LST=GMT+99 hours *NT= +8

08/98-03/99



Wed Sep 4 13:57:36 2002

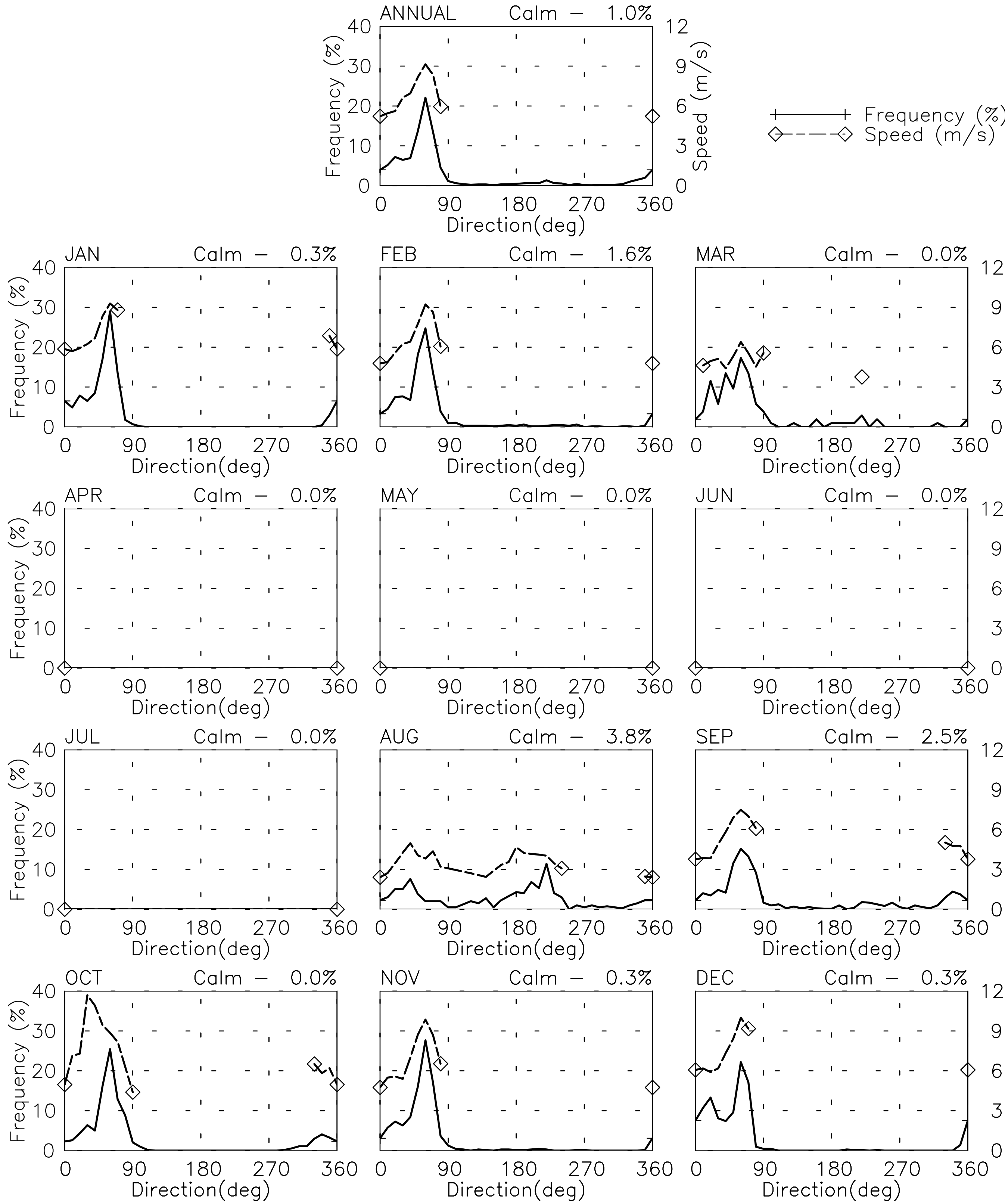

SPEED AND POWER BY HOUR
Haiwanshi 10m - 000041
23° 01' N 116° 33' E - Elev 15m LST=GMT+99 hours *NT= +8
08/98-03/99
ANNUAL V= 5.5 P= 193
JAN V= 6.3 P= 208
FEB V= 5.7 P= 197
MAR V= 4.1 P= 59
APR
MAY
JUN
JUL
AUG V= 2.4 P= 18
SEP V= 4.2 P= 78
OCT V= 6.6 P= 355
NOV V= 6.2 P= 223
DEC V= 6.2 P= 208
Speed (m/s)
Power (W/m²)
Daylight
Hour
Wed Sep 4 13:57:49 2002

FREQUENCY AND SPEED BY DIRECTION

Haiwanshi 25m – 000040

23° 01' N 116° 33' E – Elev 15m LST=GMT+99 hours *NT= +8

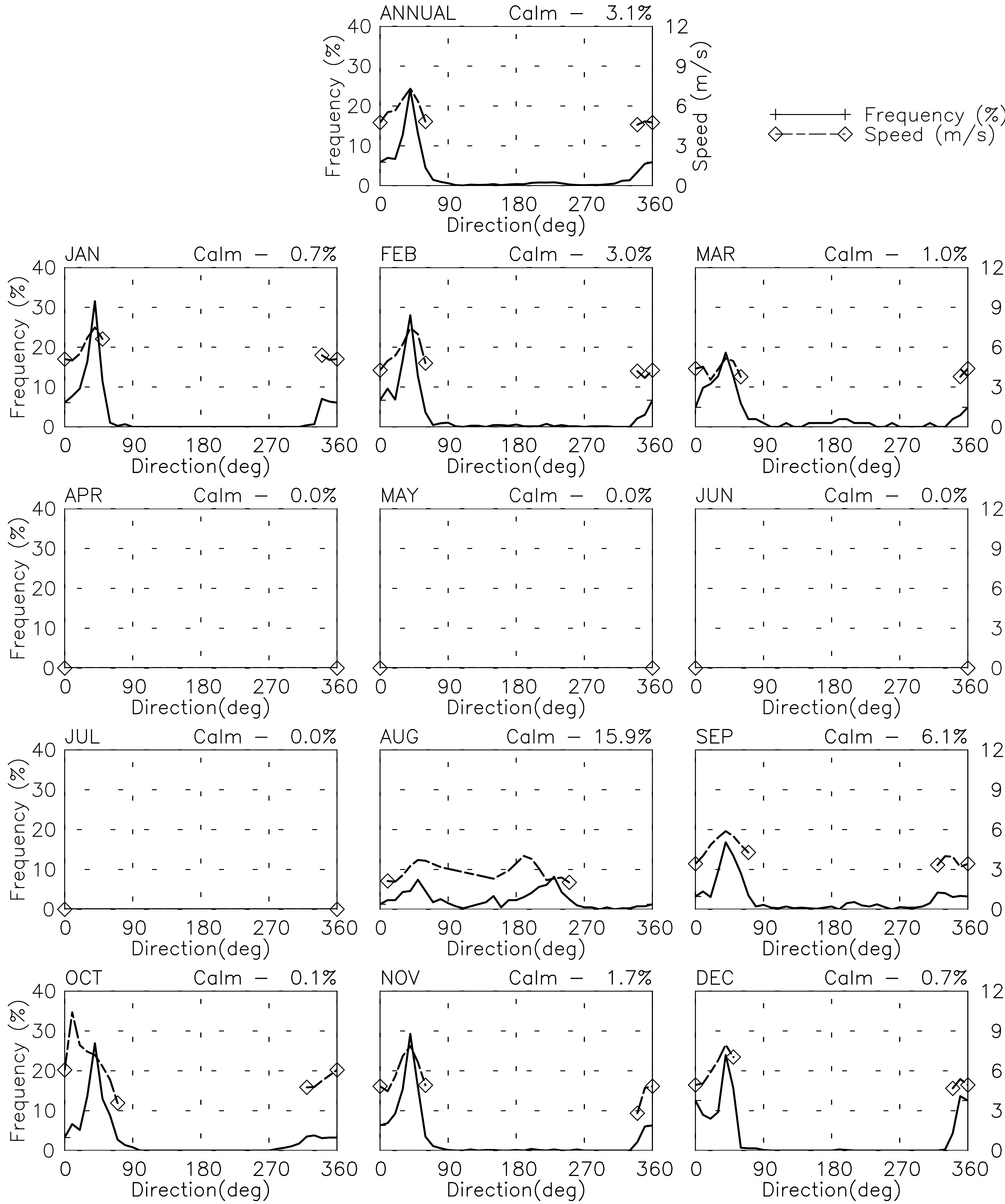
08/98–03/99



Wed Sep 4 13:57:39 2002

FREQUENCY AND SPEED BY DIRECTION

Haiwanshi 10m – 000041
23° 01' N 116° 33' E – Elev 15m LST=GMT+99 hours *NT= +8
08/98–03/99



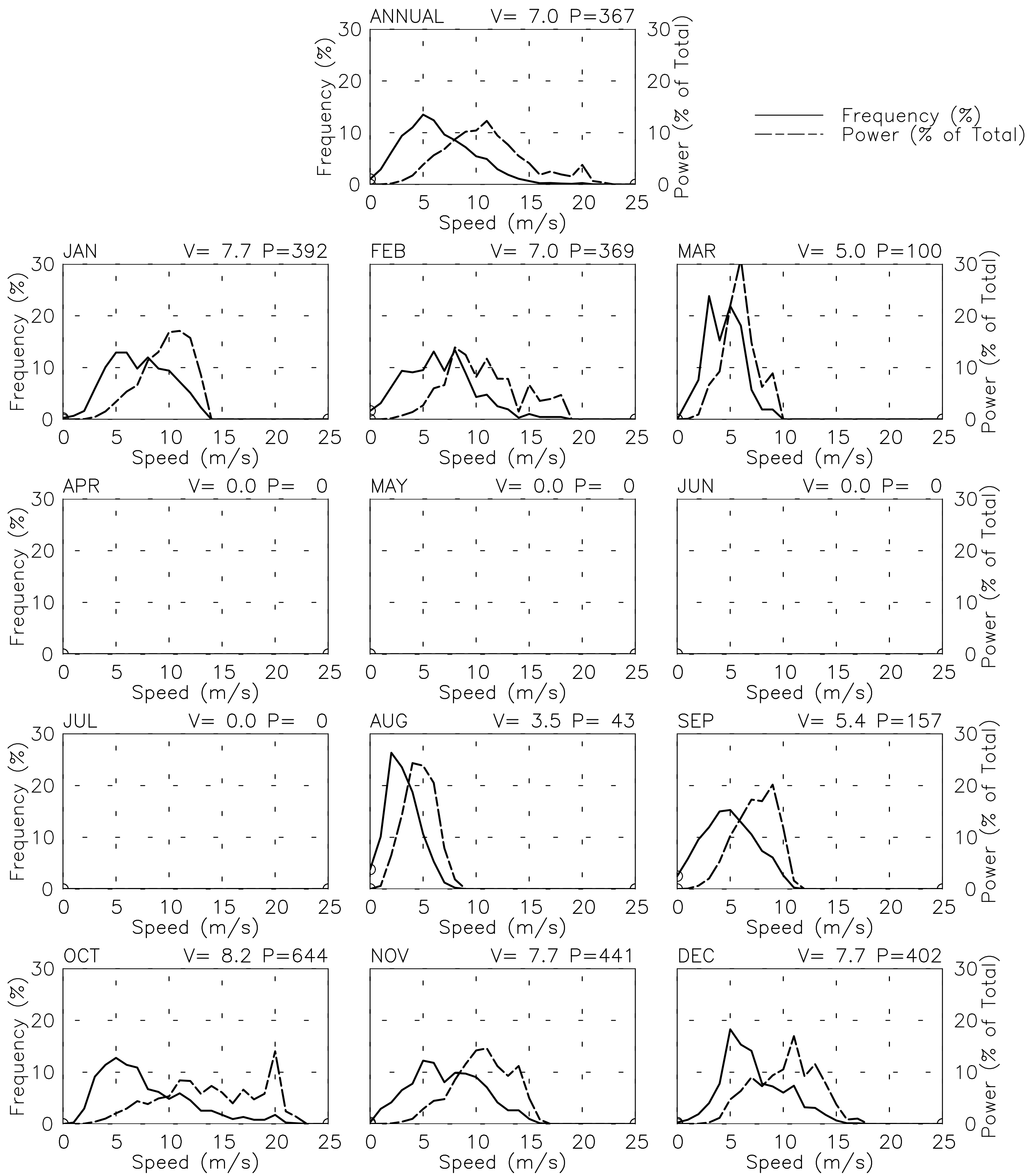
Wed Sep 4 13:57:52 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

Haiwanshi 25m – 000040

23° 01' N 116° 33' E – Elev 15m LST=GMT+99 hours *NT= +8

08/98–03/99



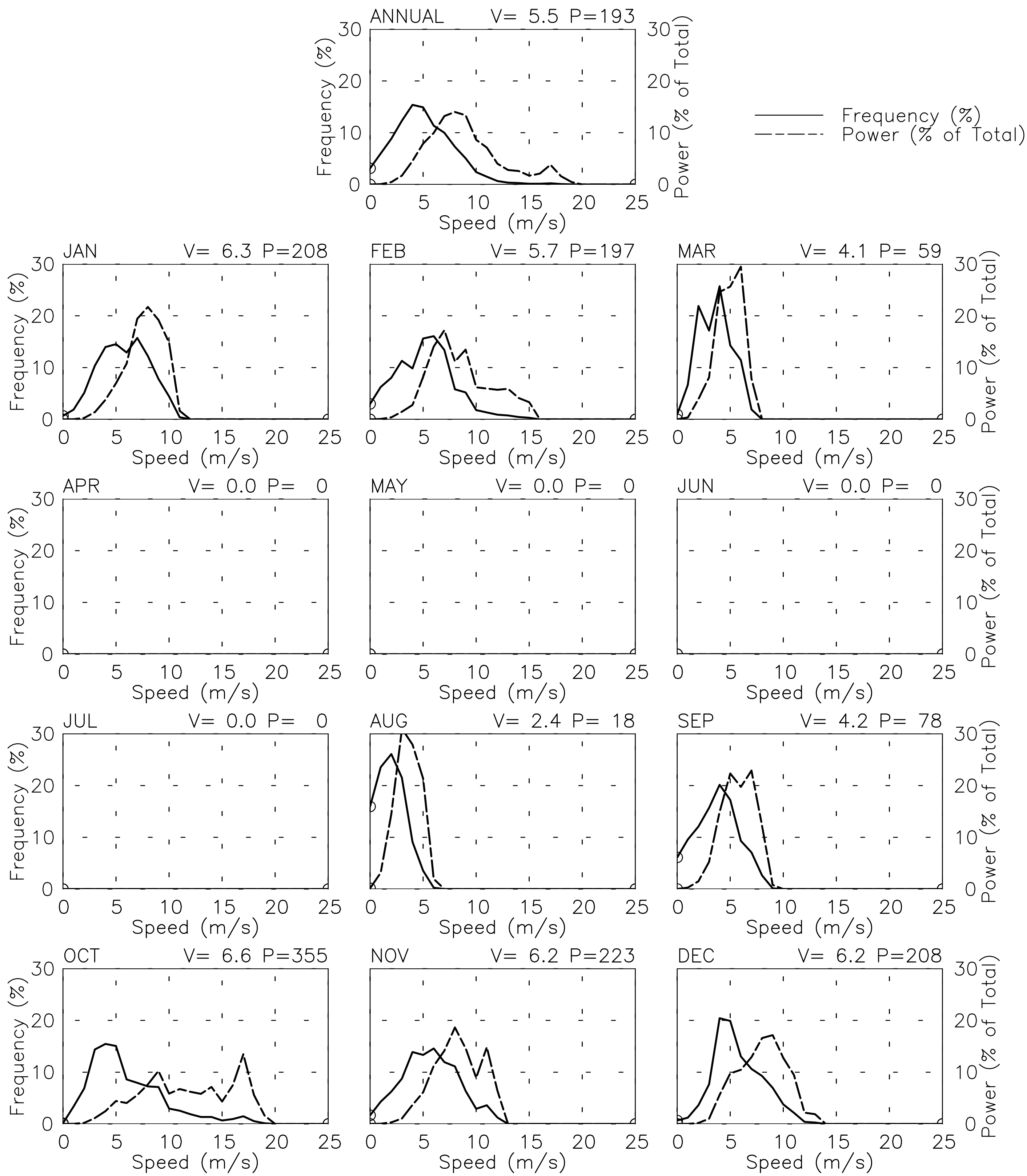
Wed Sep 4 13:57:42 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

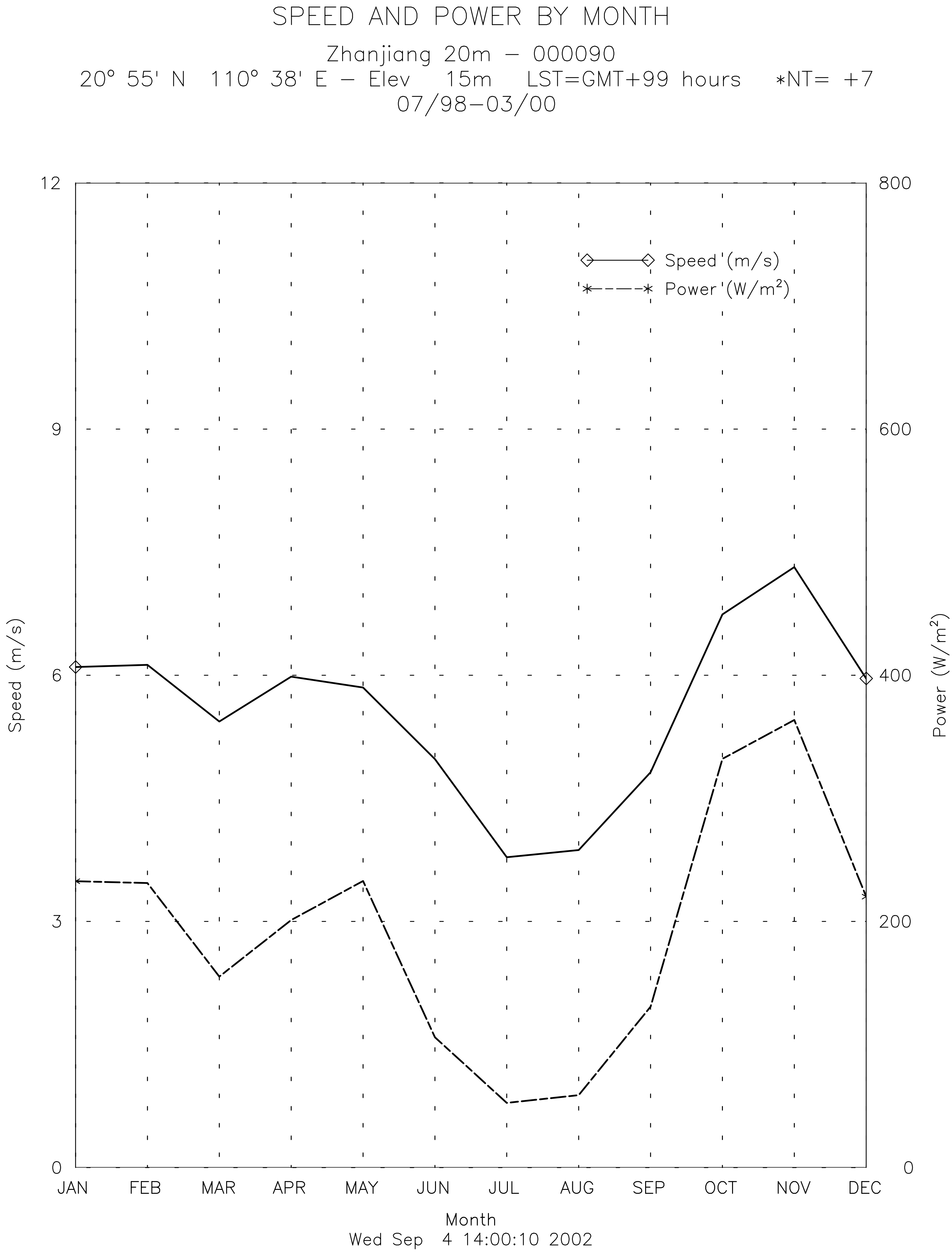
Haiwanshi 10m – 000041

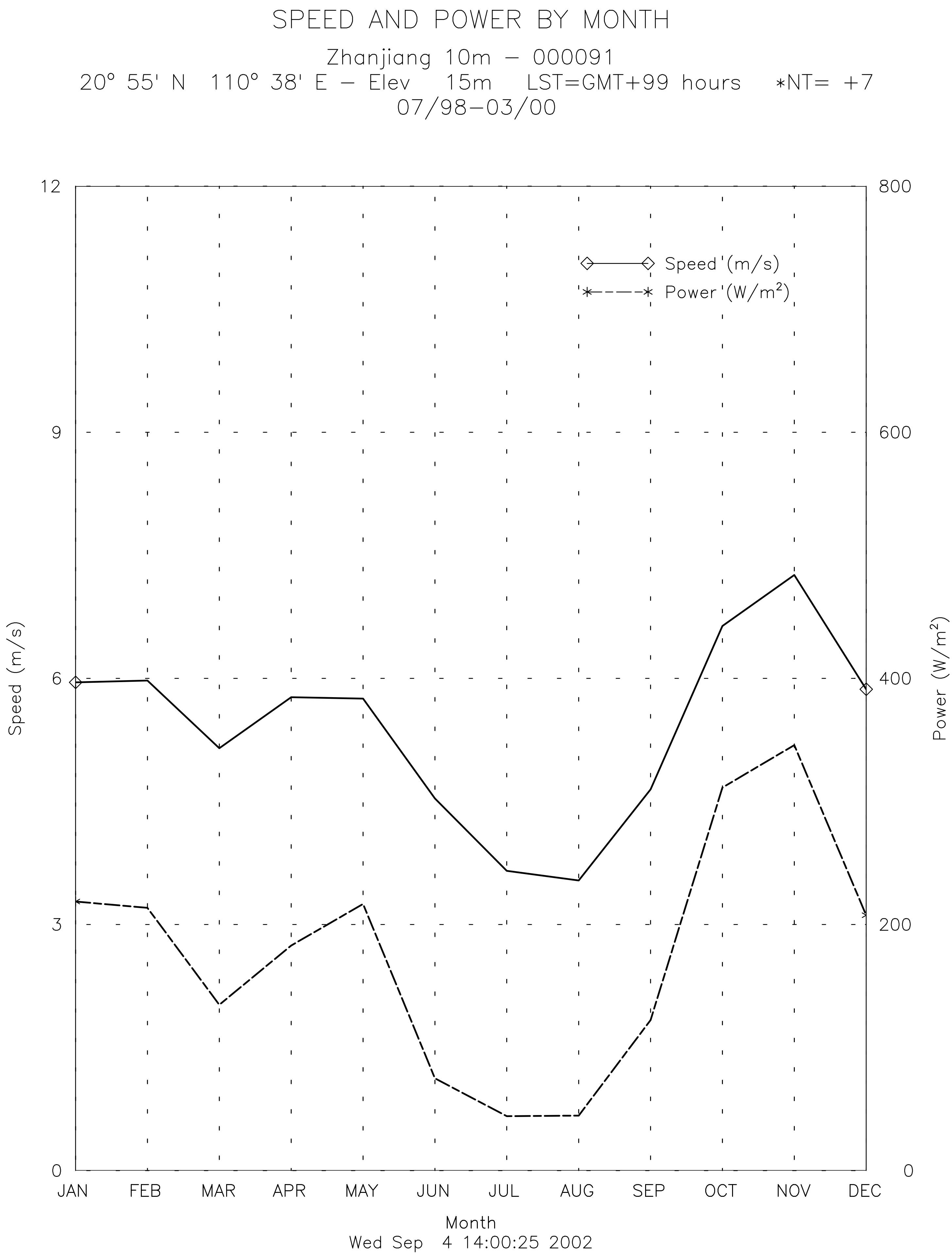
23° 01' N 116° 33' E – Elev 15m LST=GMT+99 hours *NT= +8

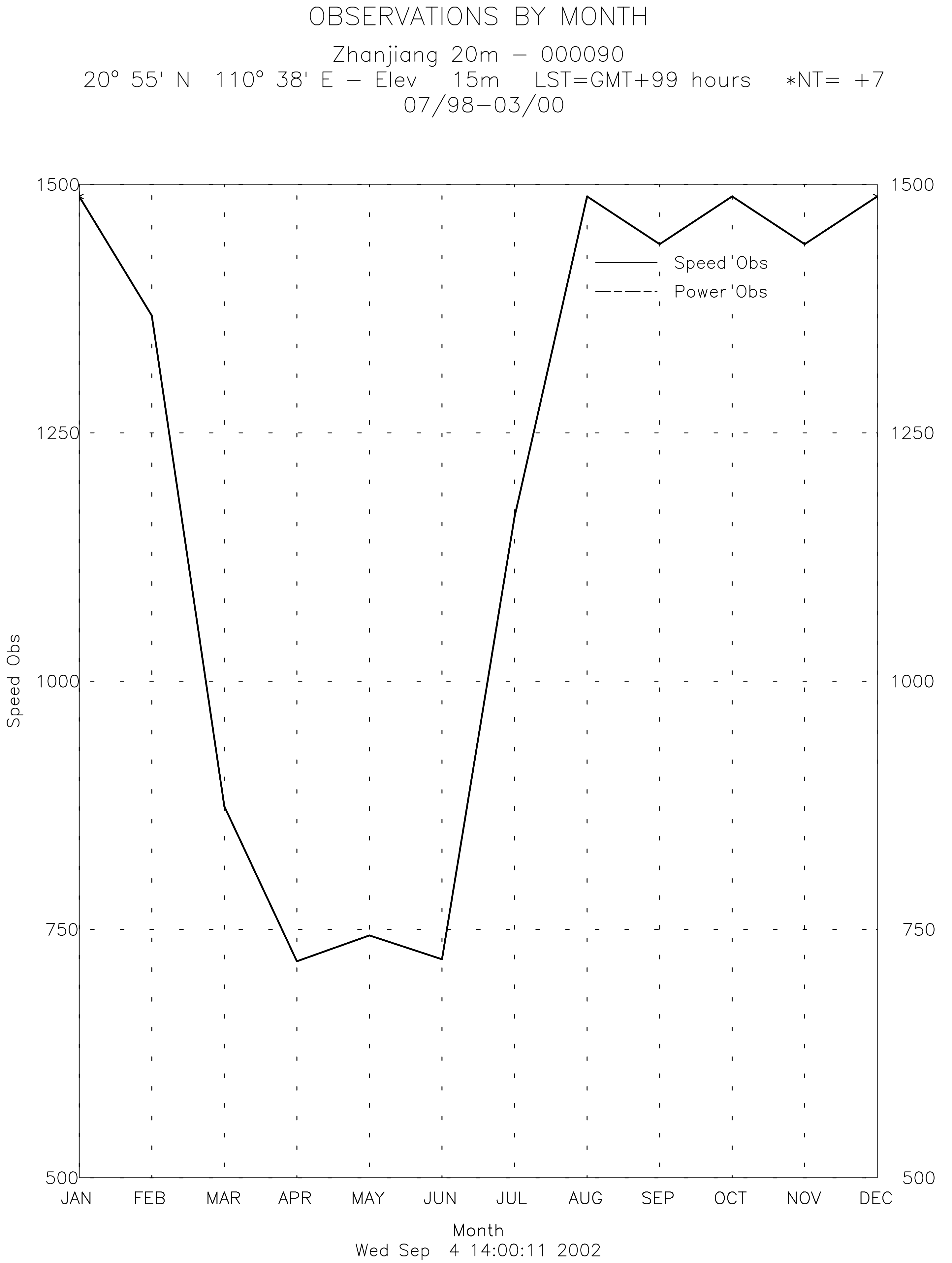
08/98–03/99



Wed Sep 4 13:57:55 2002

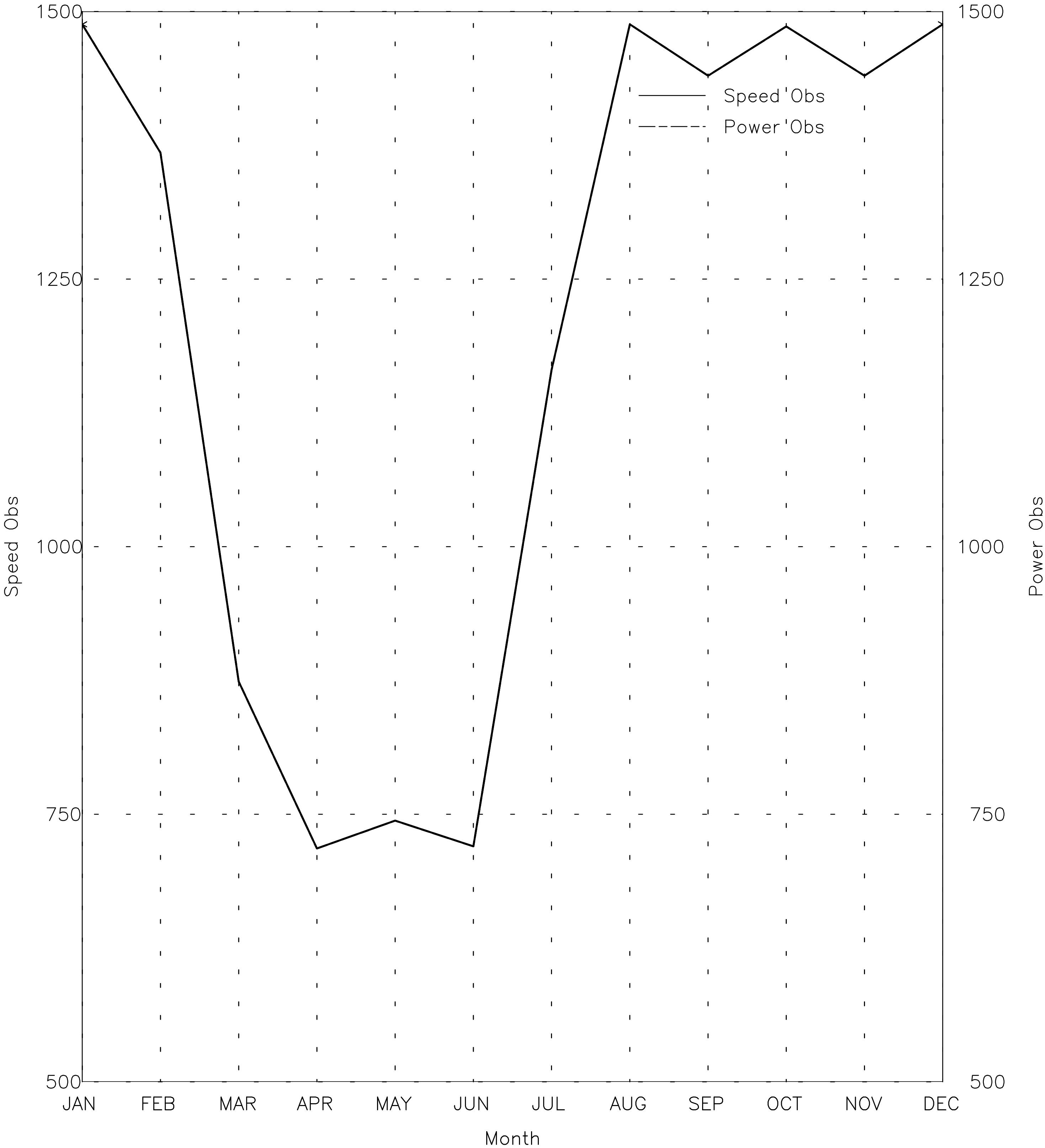

SPEED AND POWER BY MONTH
Zhanjiang 20m - 000090
20° 55' N 110° 38' E - Elev 15m LST=GMT+99 hours *NT= +7
07/98-03/00
Speed (m/s)
Power (W/m²)
Speed (m/s)
Power (W/m²)
12
9
6
3
0
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 14:00:10 2002


SPEED AND POWER BY MONTH
Zhanjiang 10m - 000091
20° 55' N 110° 38' E - Elev 15m LST=GMT+99 hours *NT= +7
07/98-03/00
Speed (m/s)
Power (W/m²)
Month
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
0 3 6 9 12
0 200 400 600 800
Wed Sep 4 14:00:25 2002


OBSERVATIONS BY MONTH
Zhanjiang 20m - 000090
20° 55' N 110° 38' E - Elev 15m LST=GMT+99 hours *NT= +7
07/98-03/00
Speed'Obs
Power'Obs
1500
1250
1000
750
500
Speed Obs
Power Obs
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 14:00:11 2002

OBSERVATIONS BY MONTH

Zhanjiang 10m - 000091
20° 55' N 110° 38' E - Elev 15m LST=GMT+99 hours *NT= +7
07/98-03/00



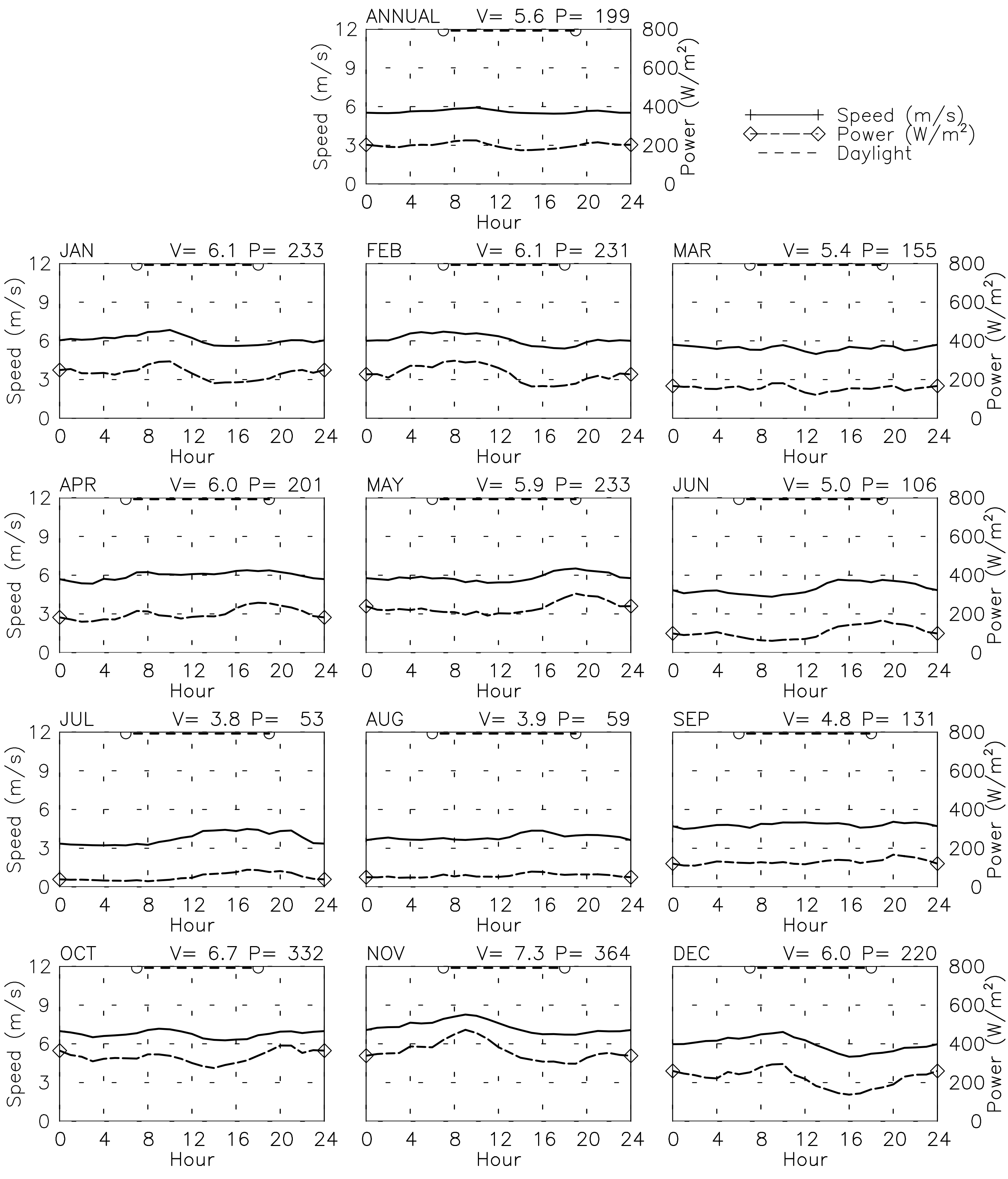
Wed Sep 4 14:00:26 2002

SPEED AND POWER BY HOUR

Zhanjiang 20m – 000090

20° 55' N 110° 38' E – Elev 15m LST=GMT+99 hours *NT= +7

07/98–03/00



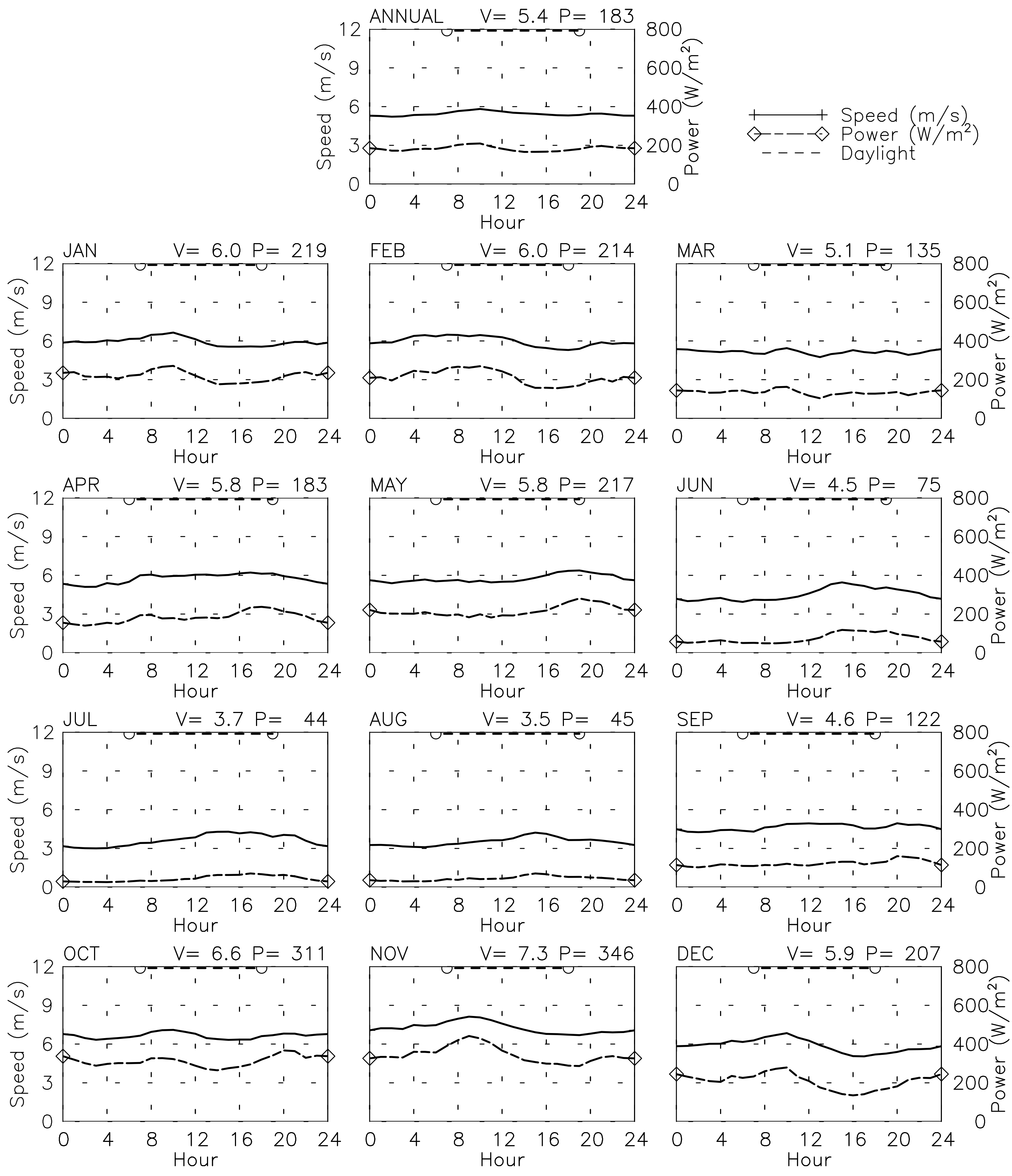
Wed Sep 4 14:00:12 2002

SPEED AND POWER BY HOUR

Zhanjiang 10m – 000091

20° 55' N 110° 38' E – Elev 15m LST=GMT+99 hours *NT= +7

07/98–03/00



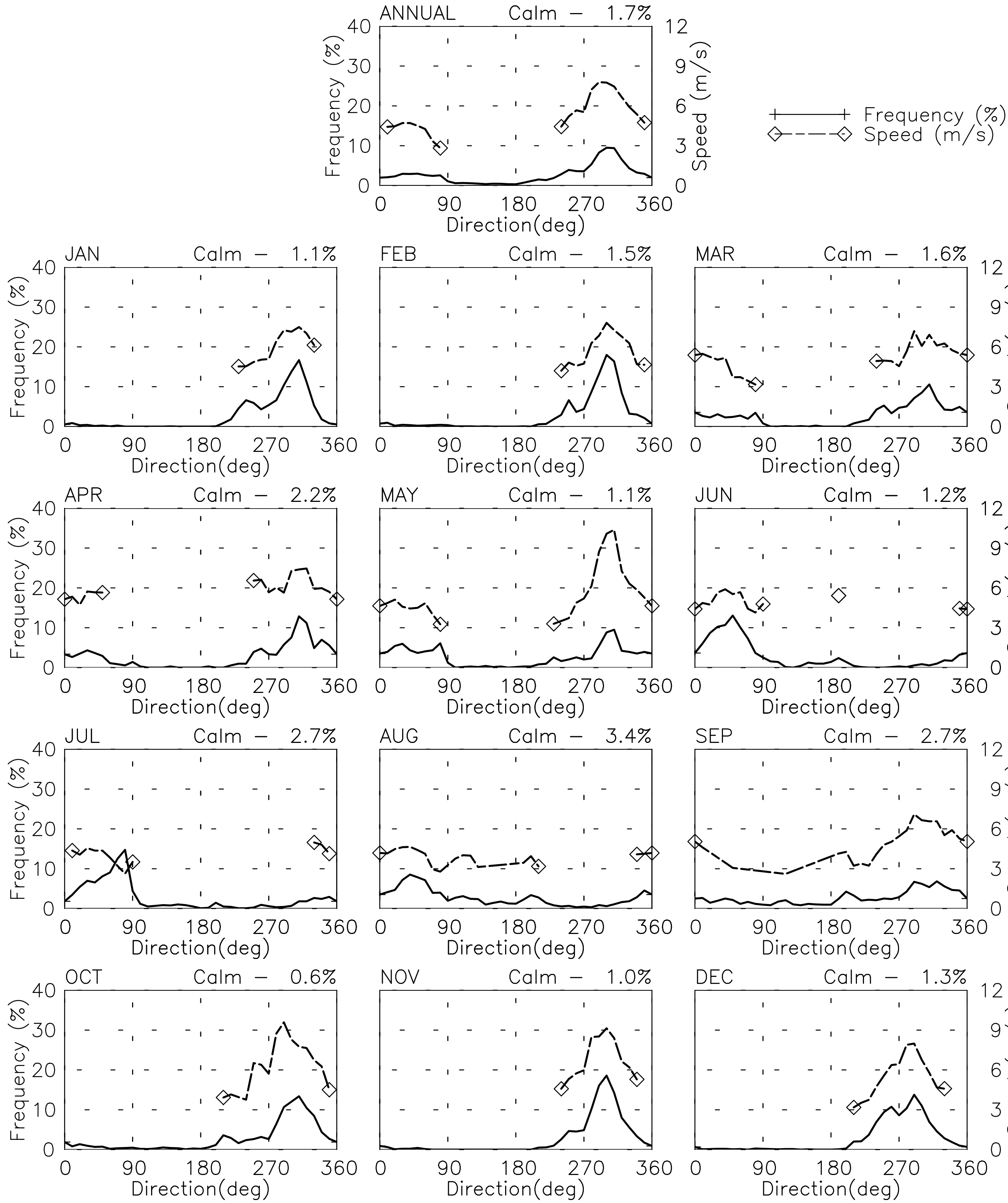
Wed Sep 4 14:00:28 2002

FREQUENCY AND SPEED BY DIRECTION

Zhanjiang 20m – 000090

20° 55' N 110° 38' E – Elev 15m LST=GMT+99 hours *NT= +7

07/98–03/00



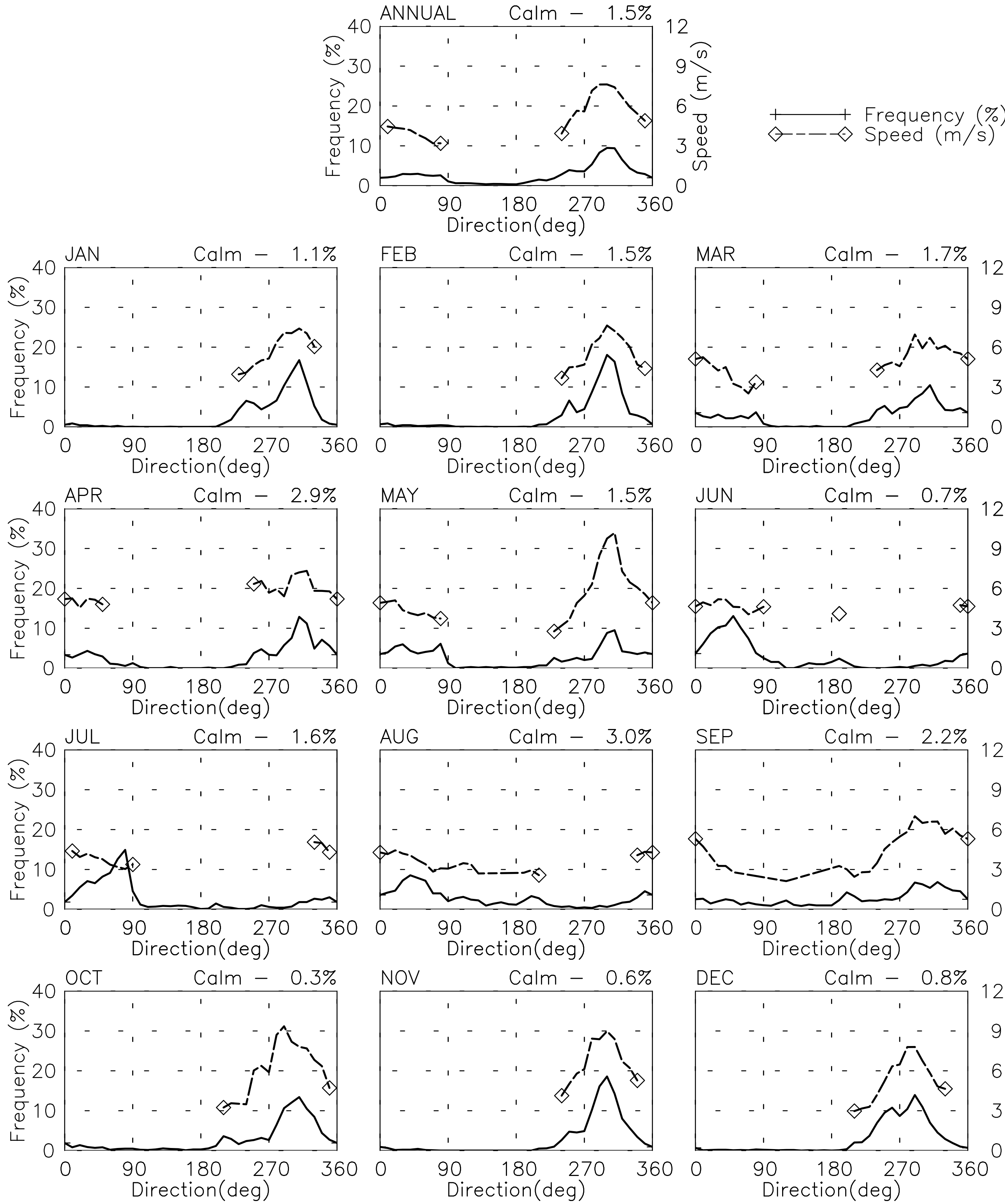
Wed Sep 4 14:00:17 2002

FREQUENCY AND SPEED BY DIRECTION

Zhanjiang 10m – 000091

20° 55' N 110° 38' E – Elev 15m LST=GMT+99 hours *NT= +7

07/98–03/00



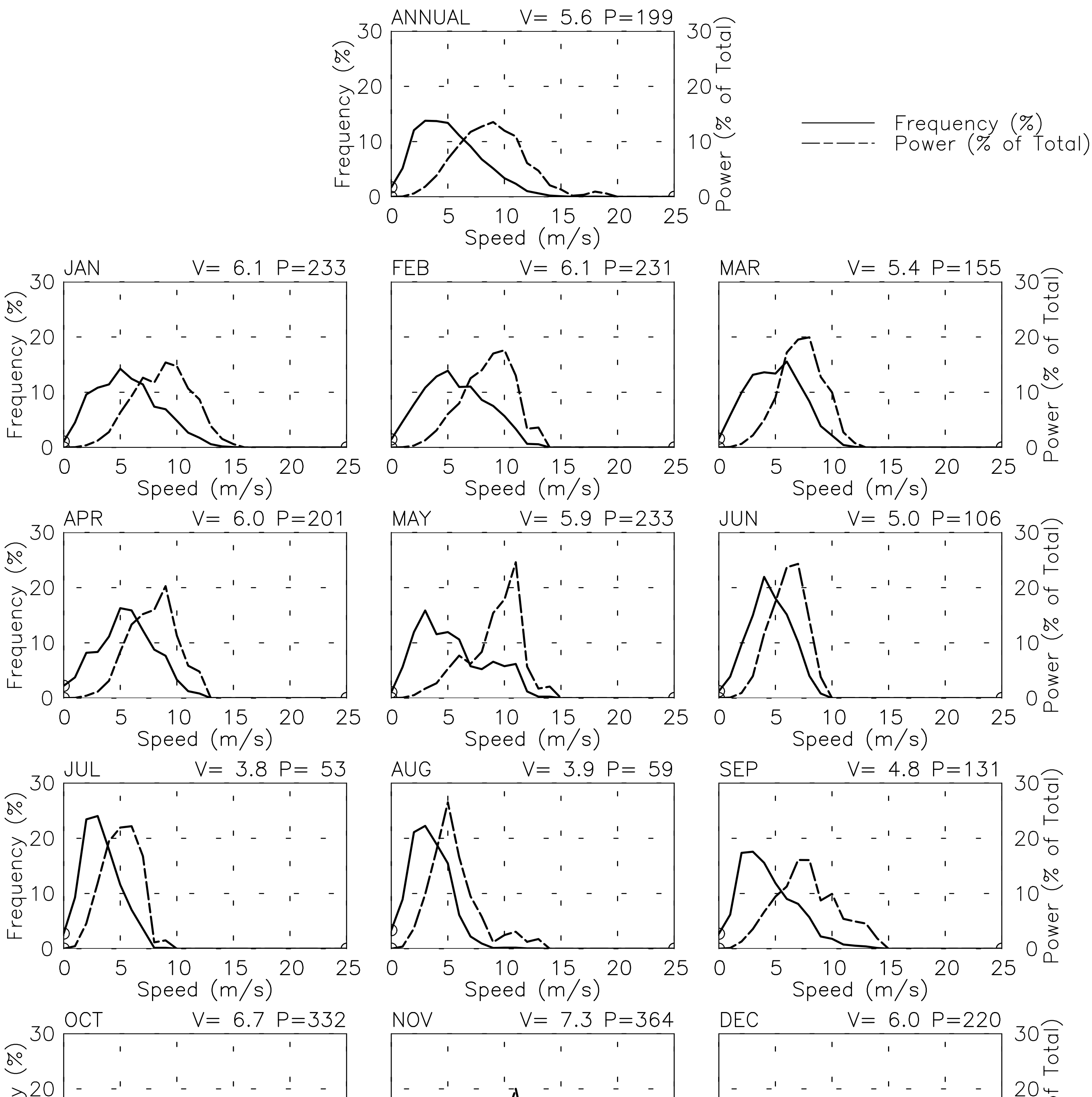
Wed Sep 4 14:00:31 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

Zhanjiang 20m – 000090

20° 55' N 110° 38' E – Elev 15m LST=GMT+99 hours *NT= +7

07/98–03/00



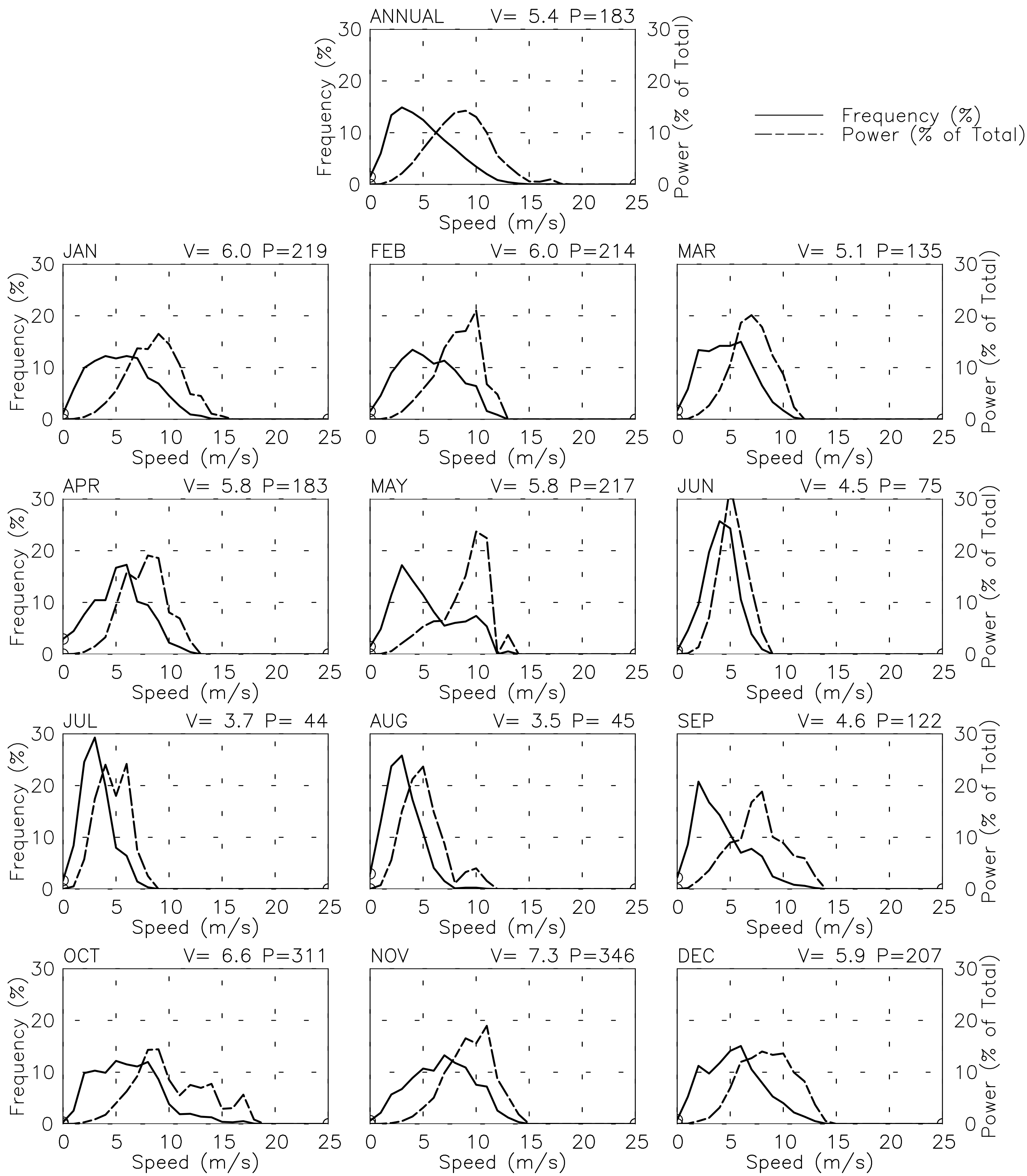
Wed Sep 4 14:00:20 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

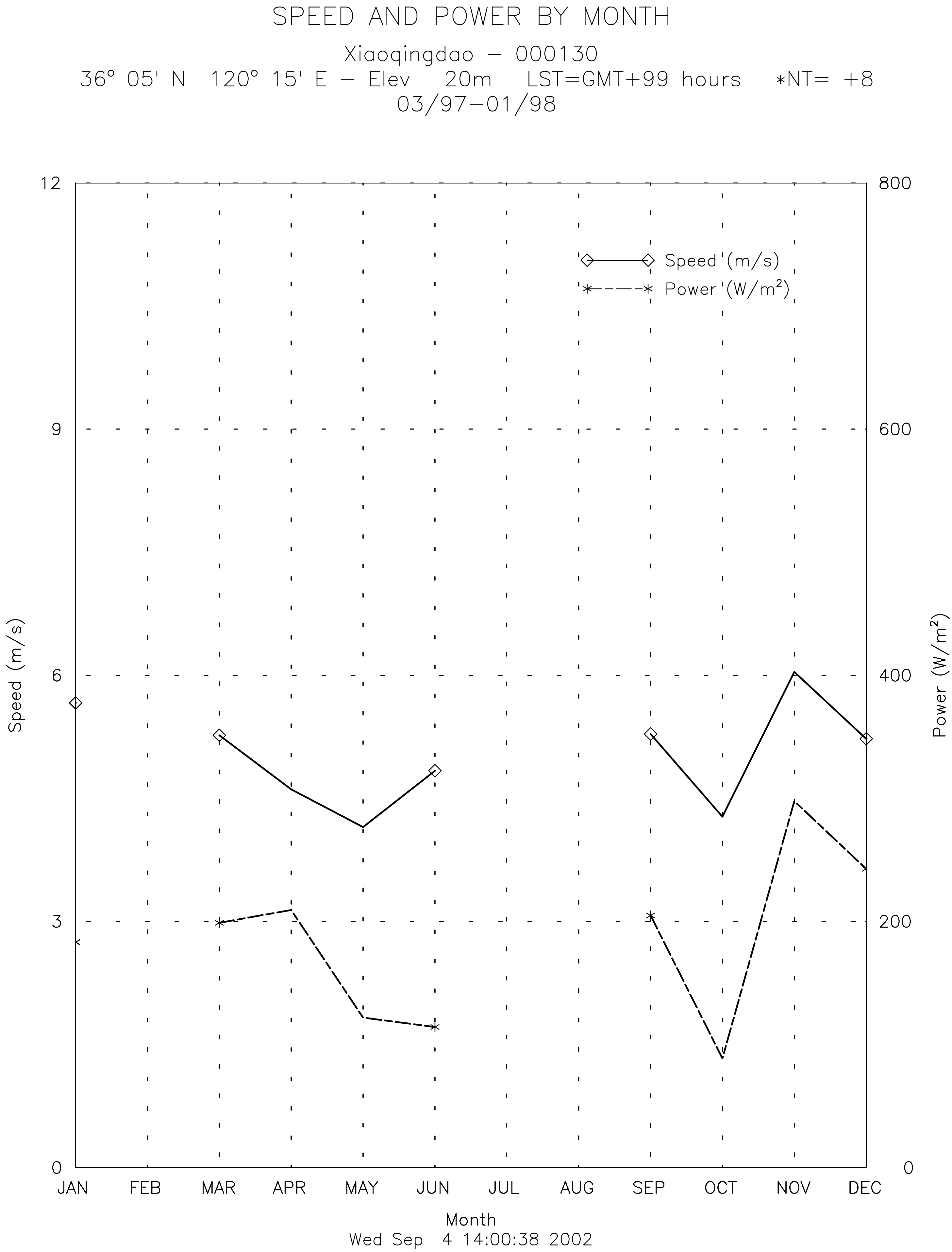
Zhanjiang 10m - 000091

20° 55' N 110° 38' E - Elev 15m LST=GMT+99 hours *NT= +7

07/98-03/00



Wed Sep 4 14:00:34 2002

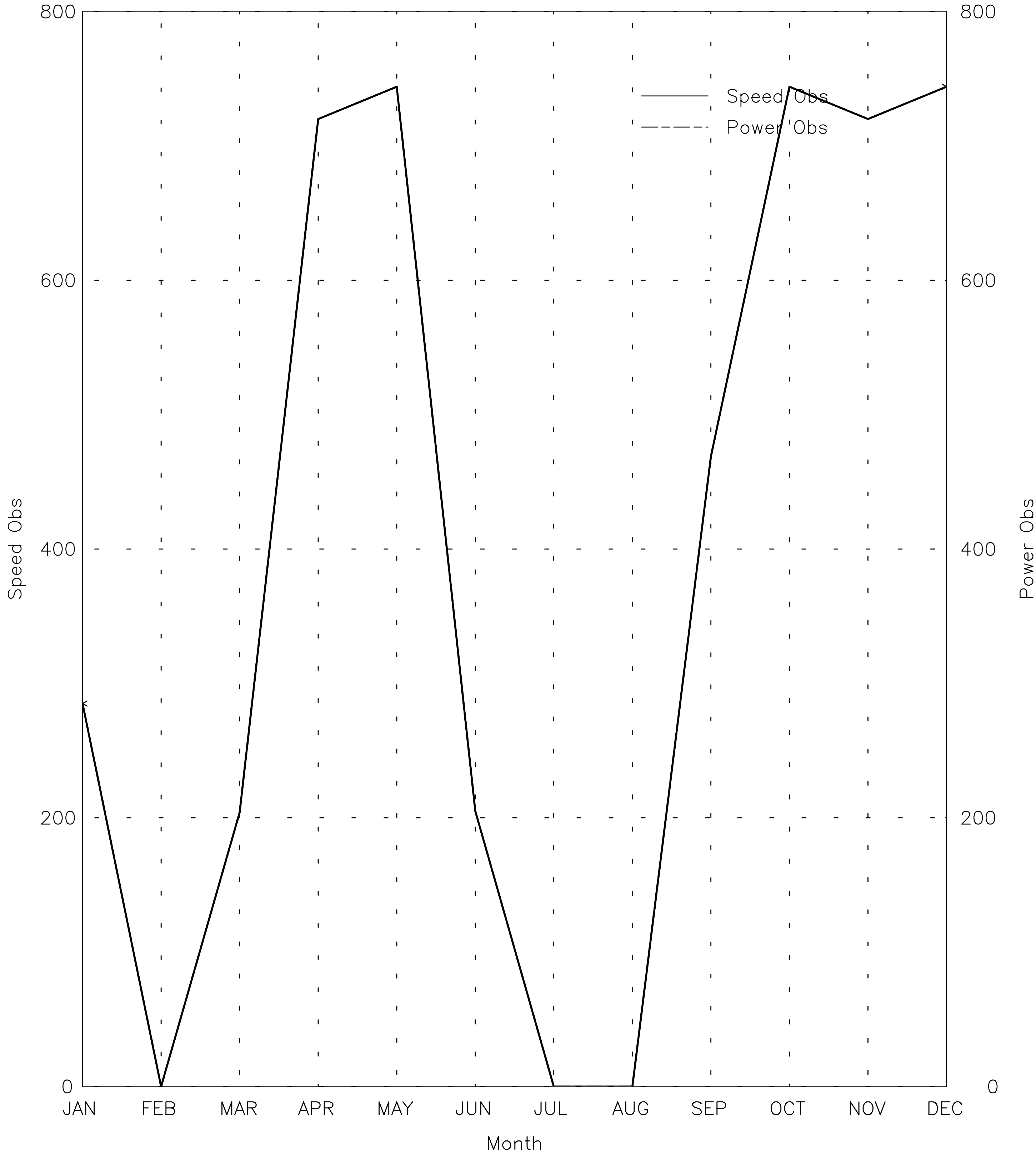

SPEED AND POWER BY MONTH
Xiaoqingdao - 000130
36° 05' N 120° 15' E - Elev 20m LST=GMT+99 hours *NT= +8
03/97-01/98
Speed (m/s)
Power (W/m²)
Speed (m/s)
Power (W/m²)
12
9
6
3
0
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 14:00:38 2002

OBSERVATIONS BY MONTH

Xiaoqingdao − 000130

36° 05' N 120° 15' E − Elev 20m LST=GMT+99 hours *NT= +8

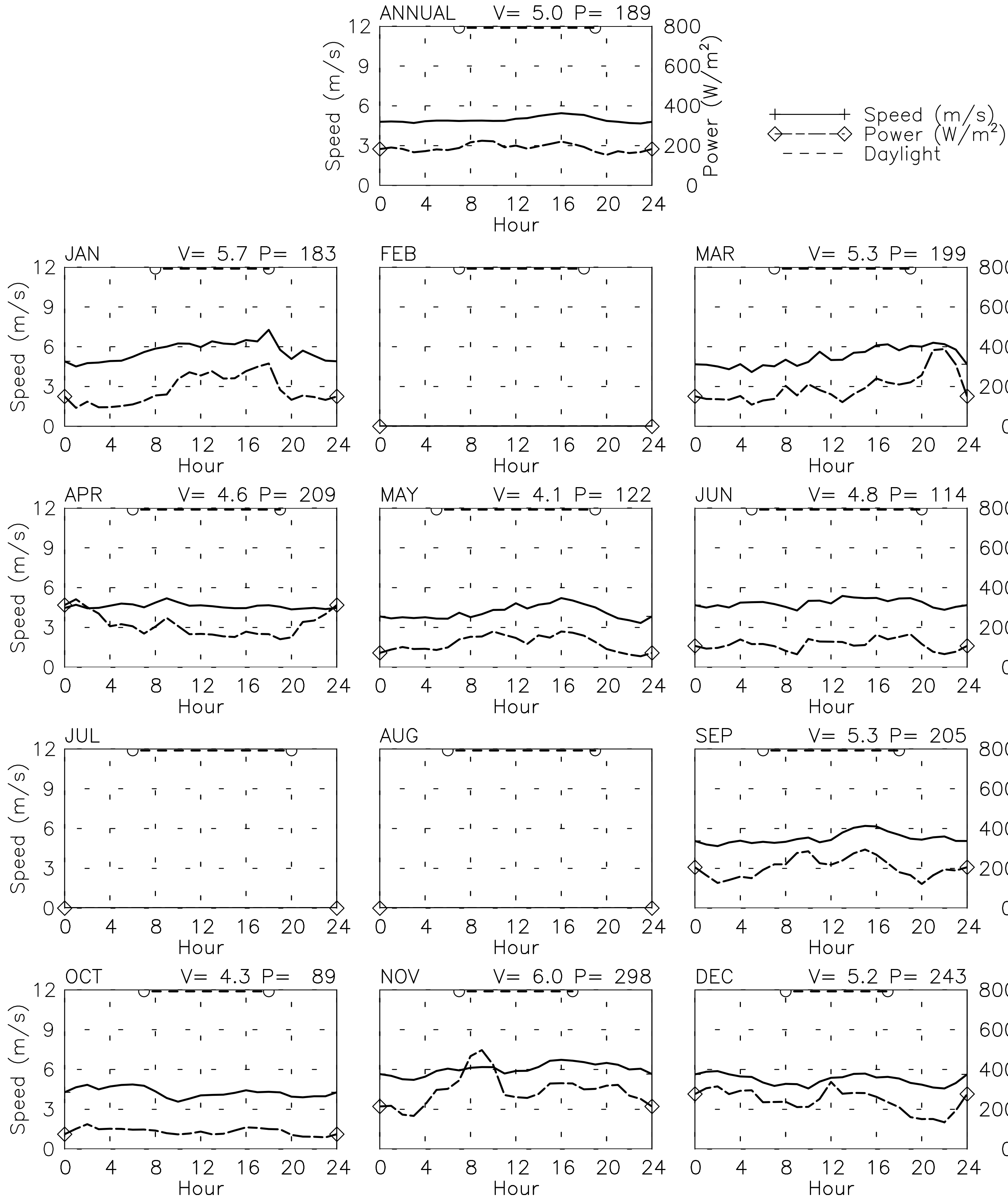
03/97−01/98



Wed Sep 4 14:00:40 2002

SPEED AND POWER BY HOUR

Xiaoqingdao – 000130
36° 05' N 120° 15' E – Elev 20m LST=GMT+99 hours *NT= +8
03/97–01/98



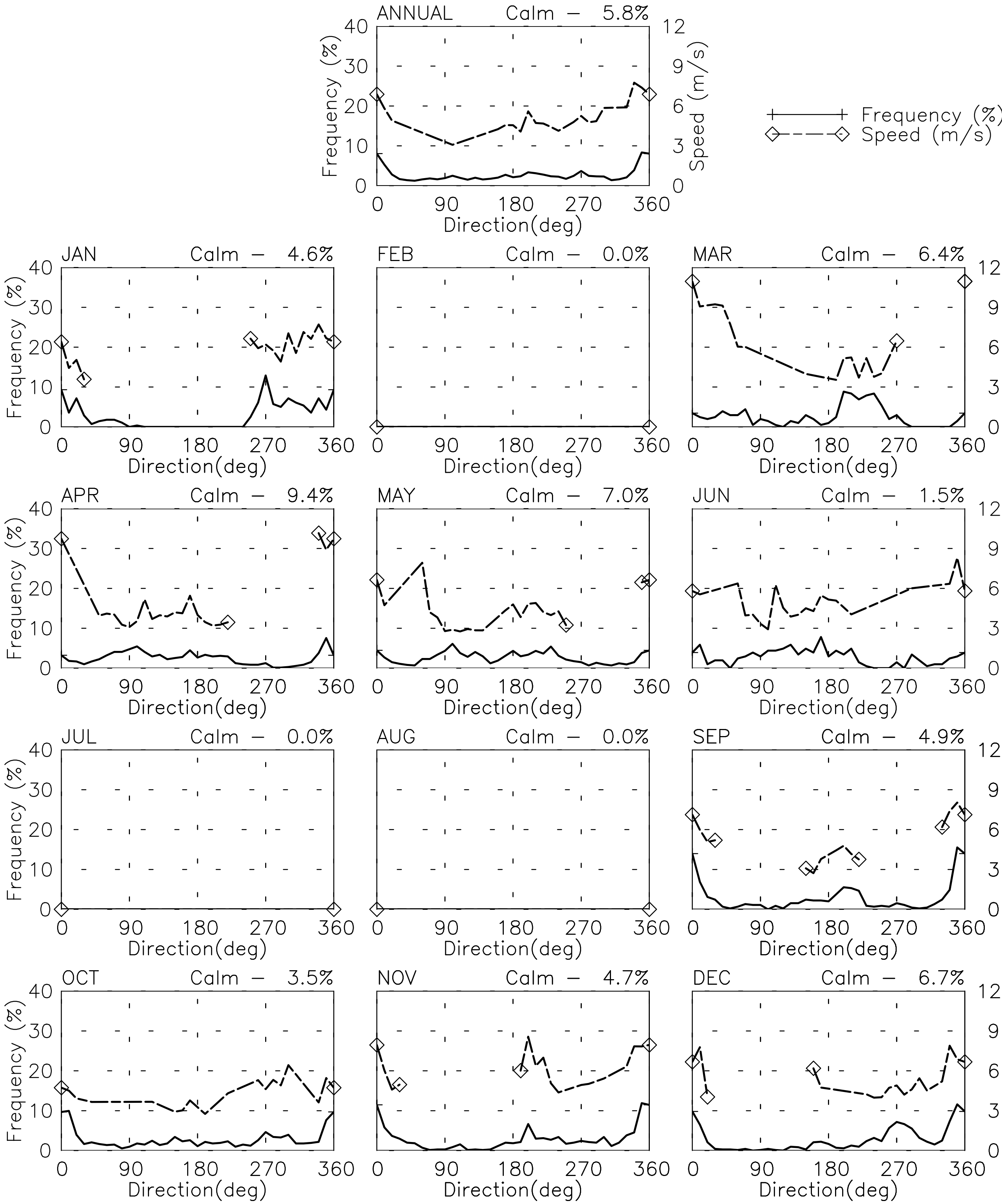
Wed Sep 4 14:00:41 2002

FREQUENCY AND SPEED BY DIRECTION

Xiaoqingdao – 000130

36° 05' N 120° 15' E – Elev 20m LST=GMT+99 hours *NT= +8

03/97–01/98



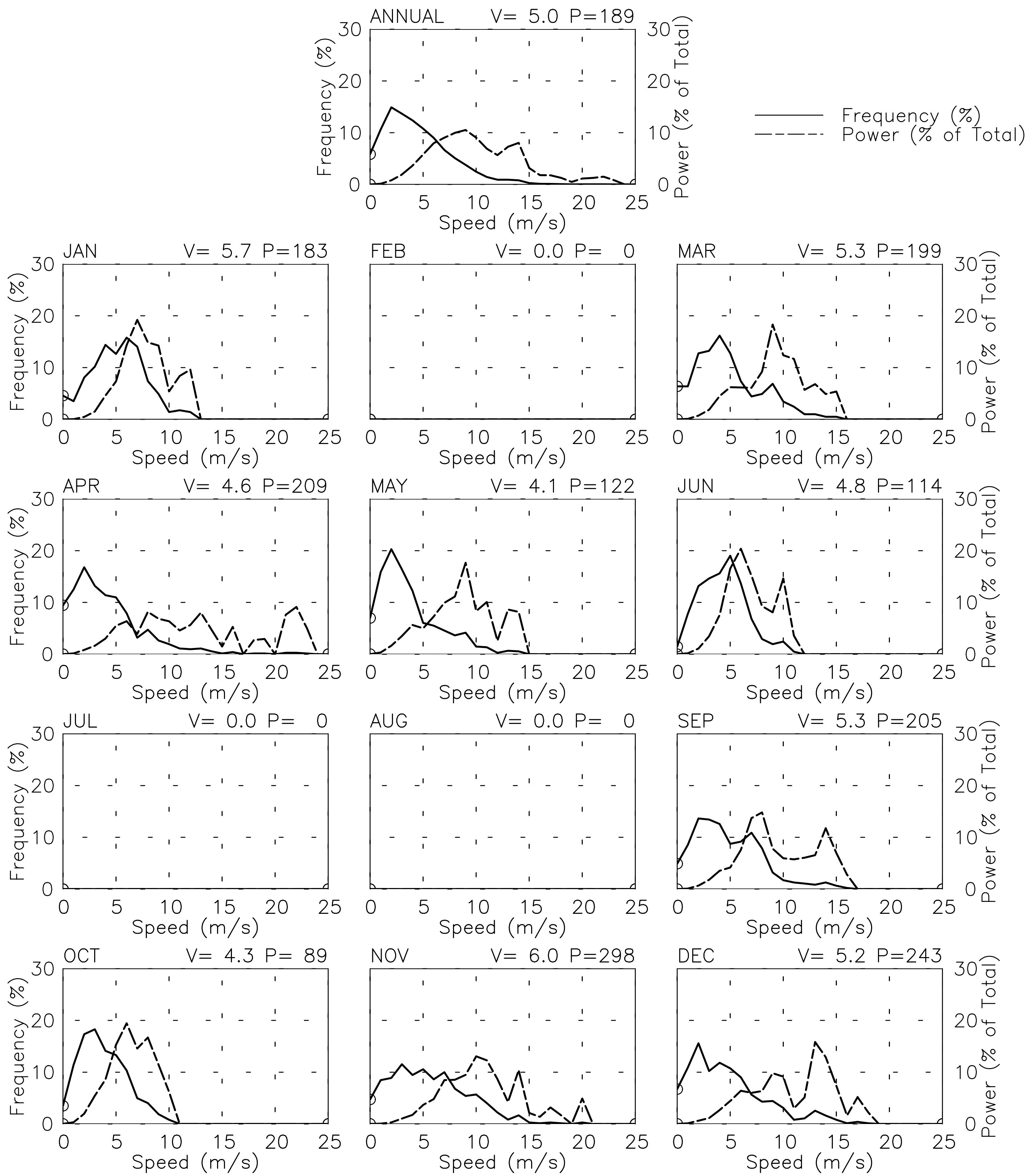
Wed Sep 4 14:00:44 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

Xiaoqingdao – 000130

36° 05' N 120° 15' E – Elev 20m LST=GMT+99 hours *NT= +8

03/97–01/98



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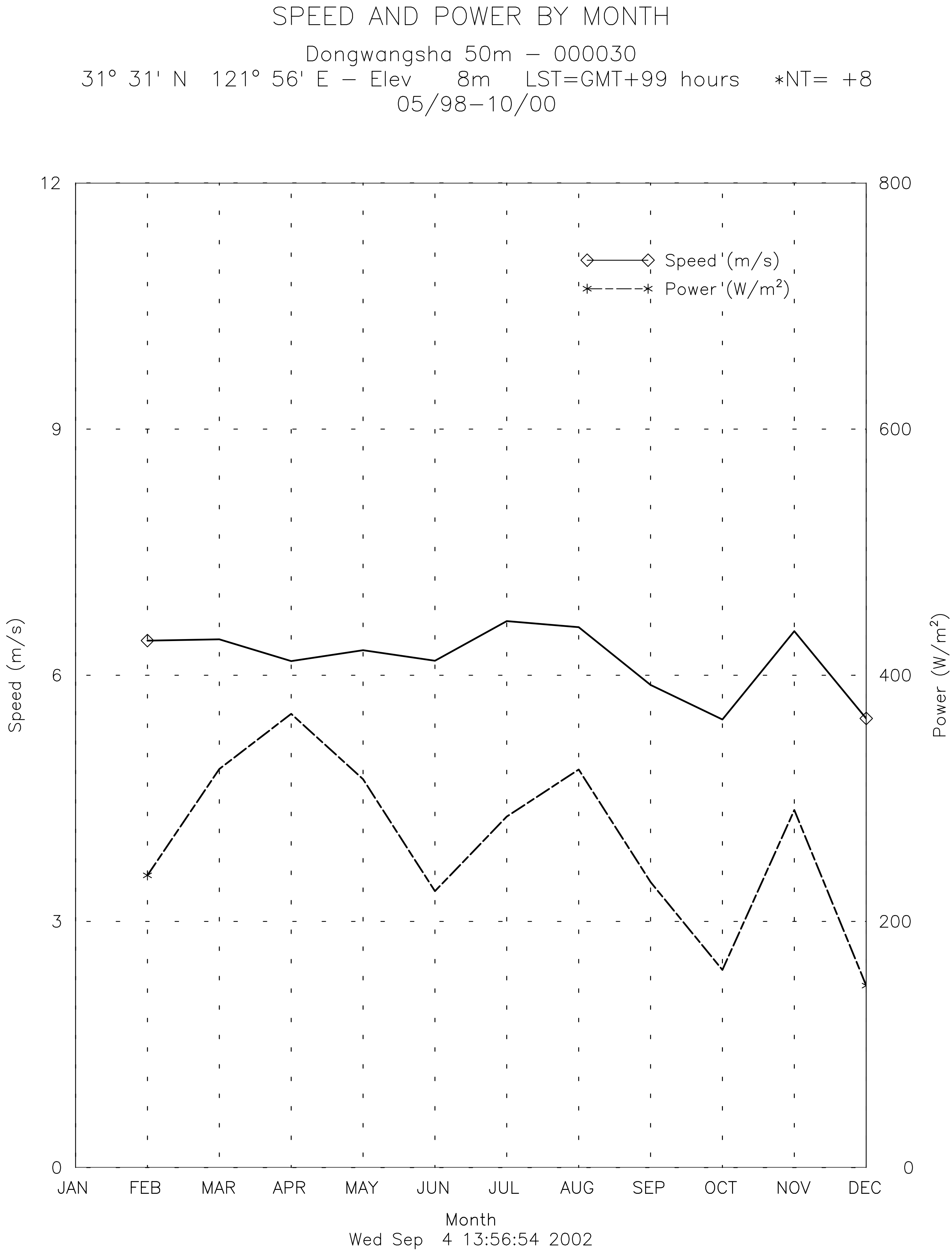
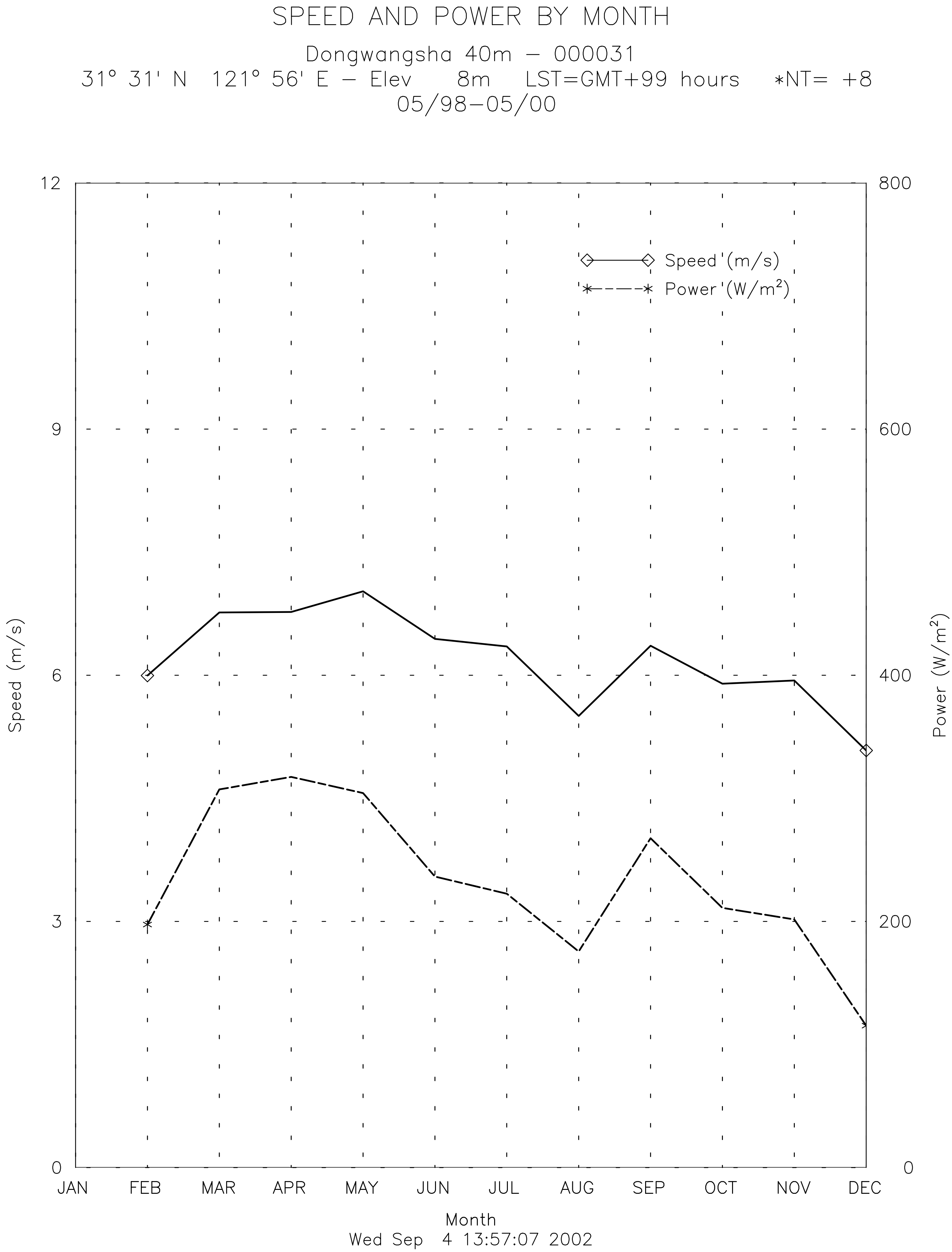

SPEED AND POWER BY MONTH
Dongwangsha 50m – 000030
31° 31' N 121° 56' E – Elev 8m LST=GMT+99 hours *NT= +8
05/98–10/00
Speed (m/s)
Power (W/m²)
12
9
6
3
0
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:56:54 2002



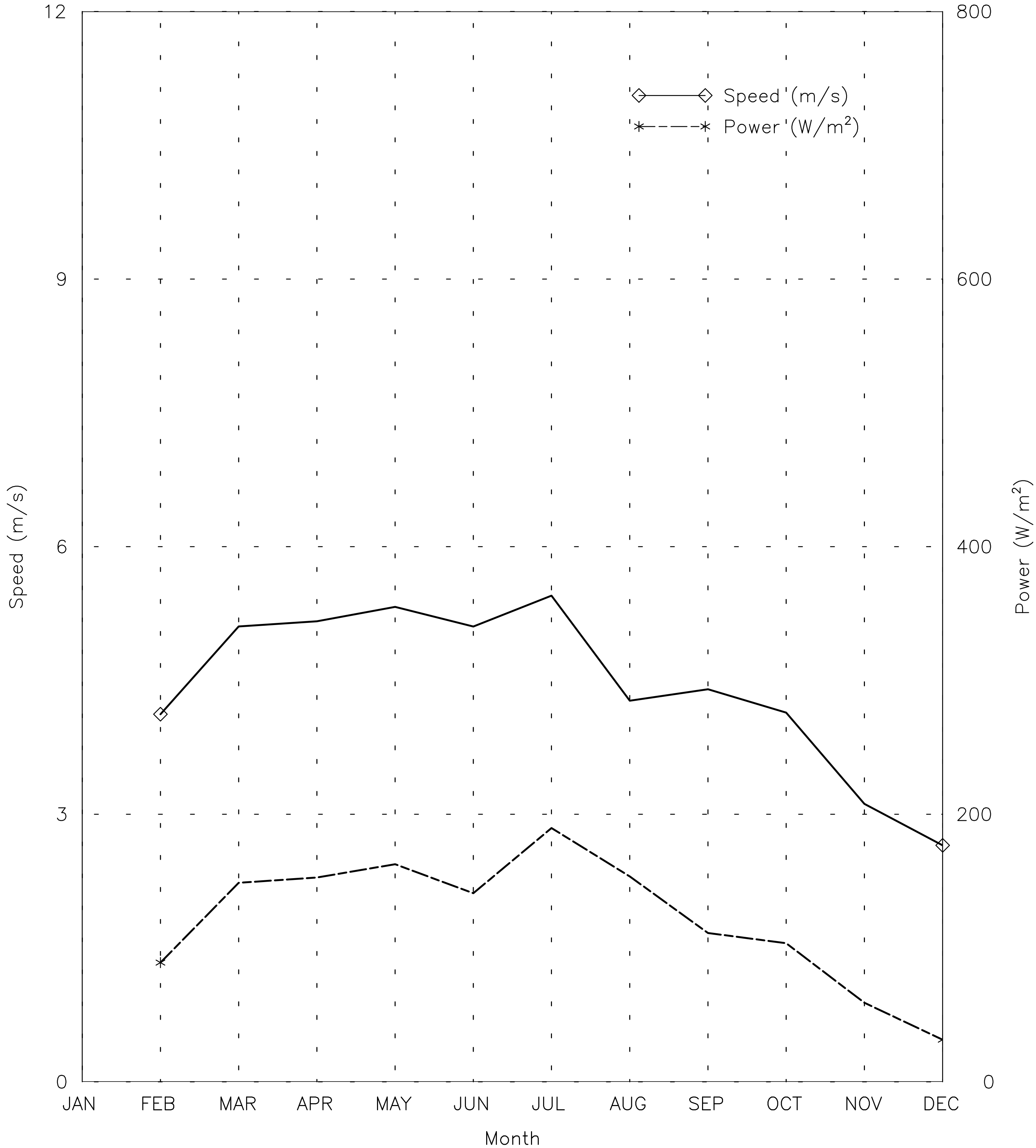
SPEED AND POWER BY MONTH
Dongwangsha 40m - 000031
31° 31' N 121° 56' E - Elev 8m LST=GMT+99 hours *NT= +8
05/98-05/00
Speed (m/s)
Power (W/m²)
Speed (m/s)
Power (W/m²)
12
9
6
3
0
800
600
400
200
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:57:07 2002

SPEED AND POWER BY MONTH

Dongwangsha 10m - 000032

31° 31' N 121° 56' E - Elev 8m LST=GMT+99 hours *NT= +8

05/98-10/00



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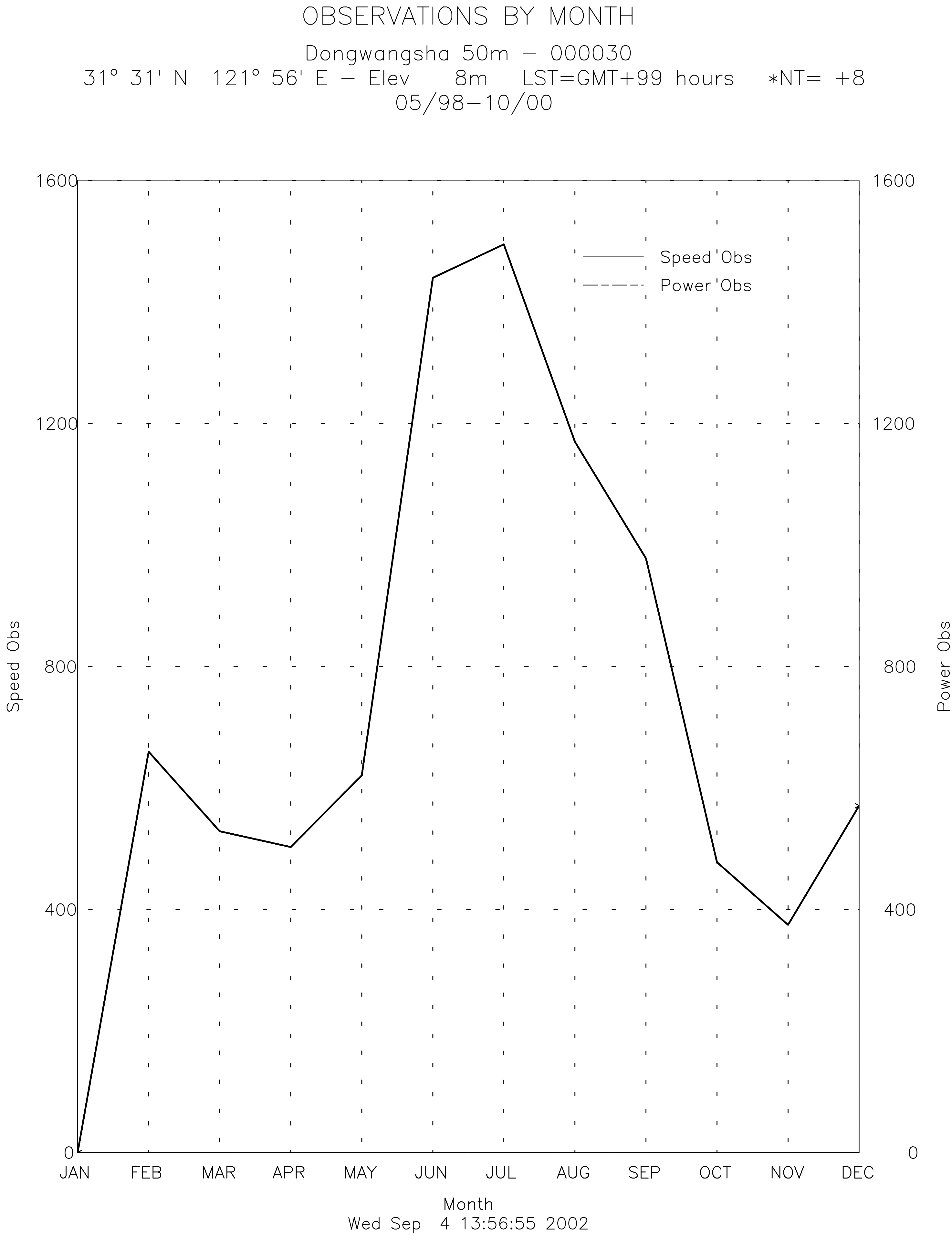
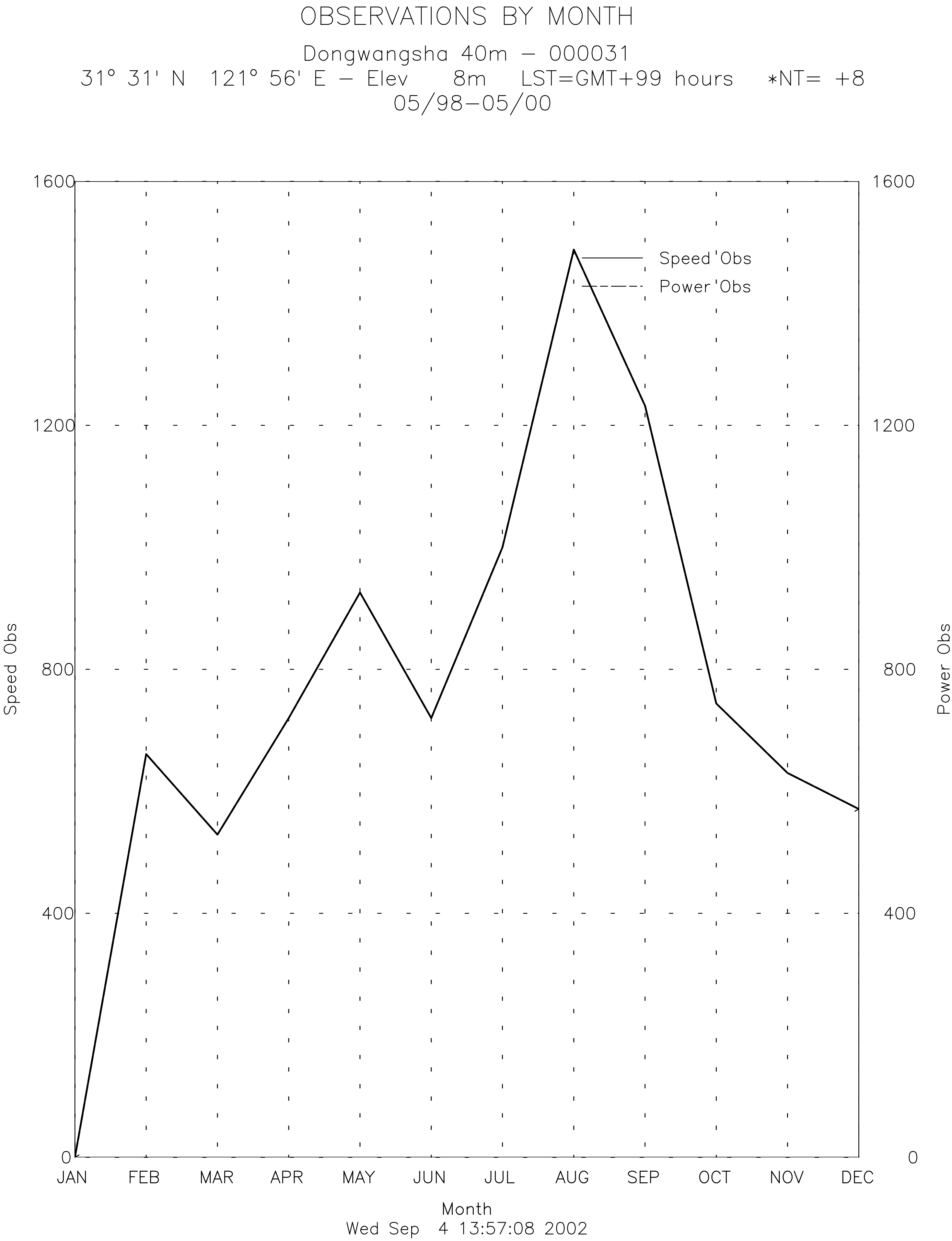


OBSERVATIONS BY MONTH
Dongwangsha 50m - 000030
31° 31' N 121° 56' E - Elev 8m LST=GMT+99 hours *NT= +8
05/98-10/00
Speed'Obs
Power'Obs
Speed Obs
Power Obs
1600
1200
800
400
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:56:55 2002


OBSERVATIONS BY MONTH
Dongwangsha 40m - 000031
31° 31' N 121° 56' E - Elev 8m LST=GMT+99 hours *NT= +8
05/98-05/00
1600
1200
800
400
0
Speed Obs
Power Obs
Speed'Obs
Power'Obs
JAN
FEB
MAR
APR
MAY
JUN
JUL
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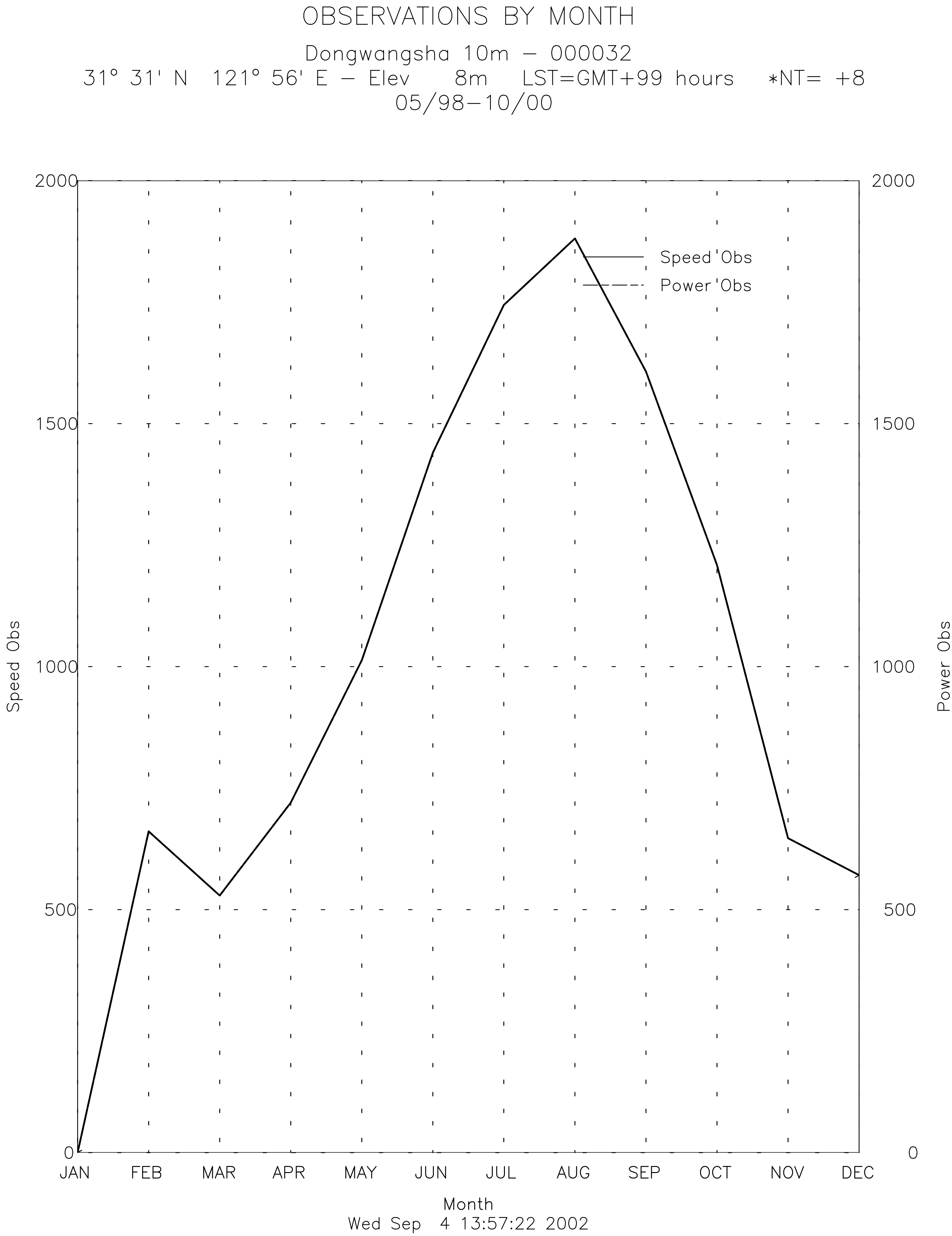
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:57:08 2002

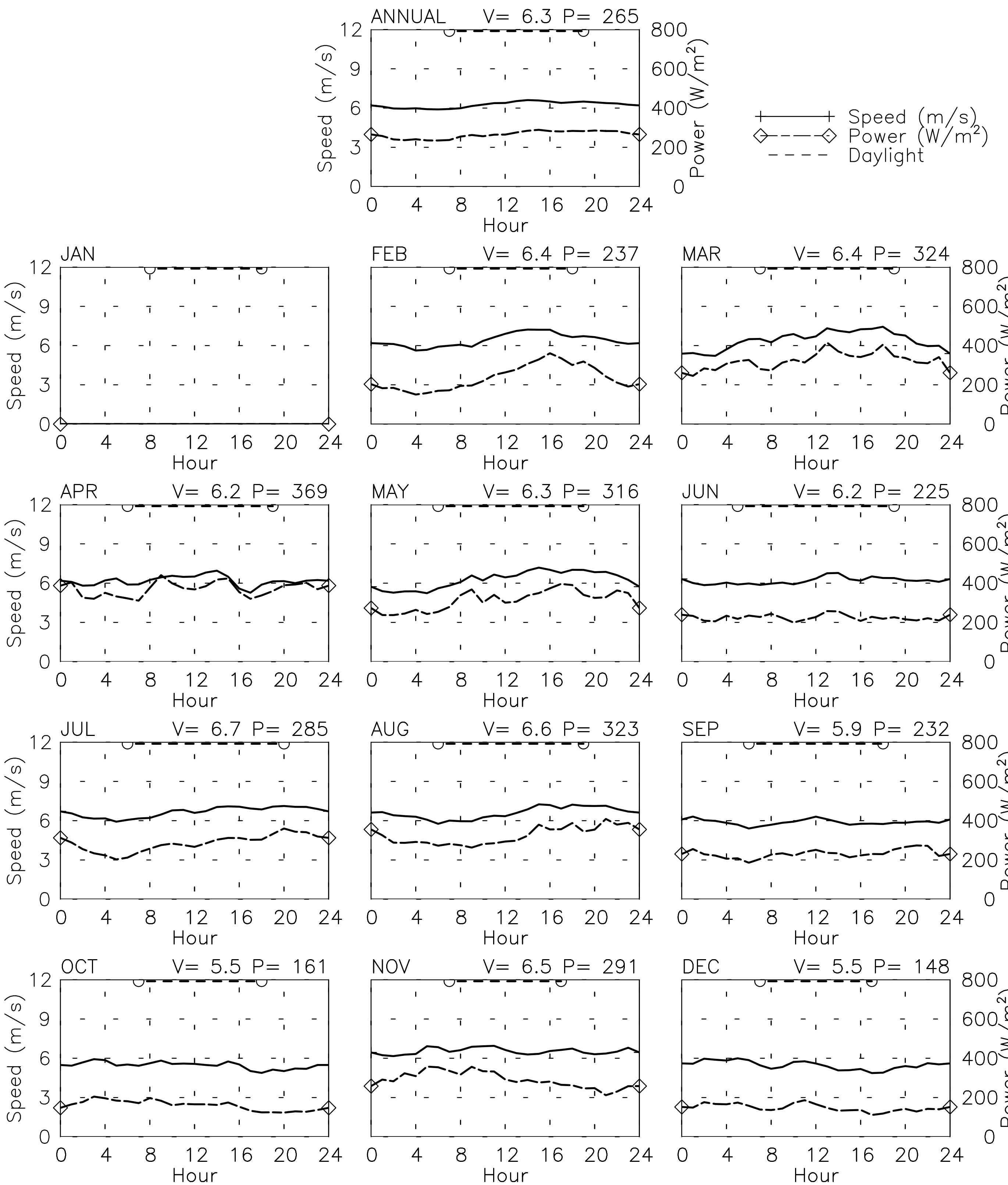

OBSERVATIONS BY MONTH
Dongwangsha 10m - 000032
31° 31' N 121° 56' E - Elev 8m LST=GMT+99 hours *NT= +8
05/98-10/00
Speed'Obs
Power'Obs
Speed Obs
Power Obs
2000
1500
1000
500
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
Month
Wed Sep 4 13:57:22 2002

SPEED AND POWER BY HOUR

Dongwangsha 50m – 000030

31° 31' N 121° 56' E – Elev 8m LST=GMT+99 hours *NT= +8

05/98–10/00



Wed Sep 4 13:56:56 2002

SPEED AND POWER BY HOUR

Dongwangsha 40m – 000031
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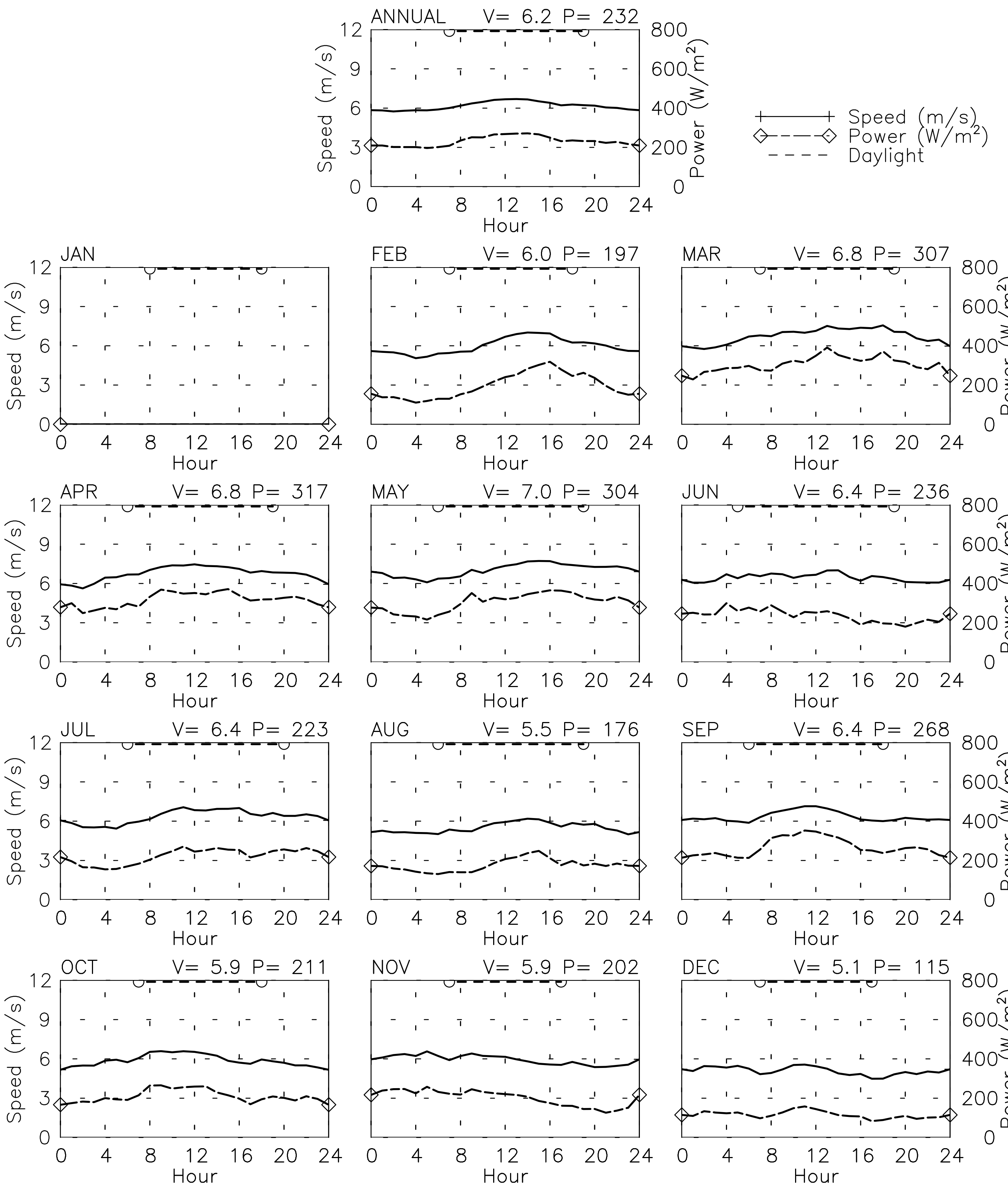
05/98–05/00



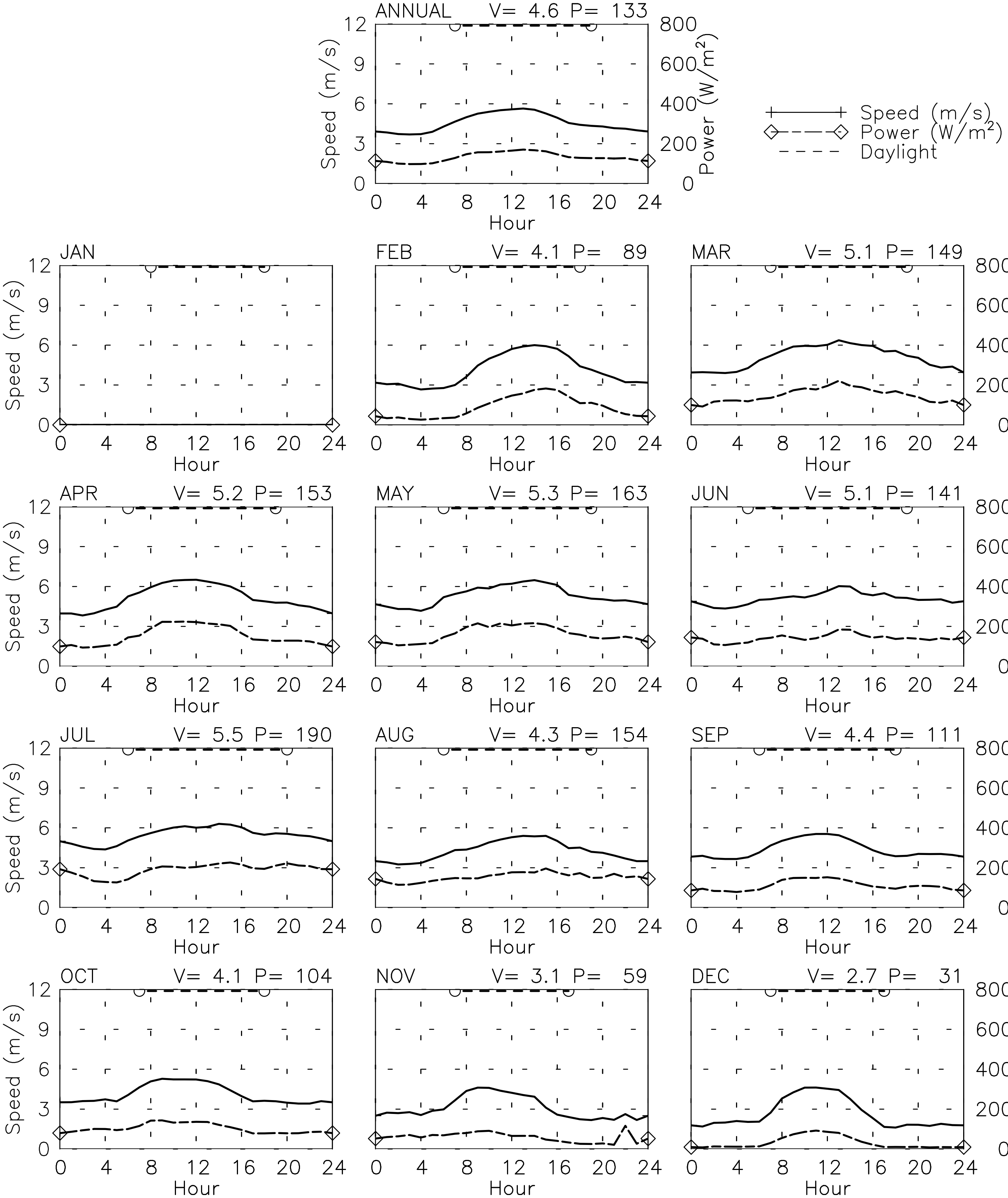
Wed Sep 4 13:57:09 2002

SPEED AND POWER BY HOUR

Dongwangsha 10m – 000032

31° 31' N 121° 56' E – Elev 8m LST=GMT+99 hours *NT= +8

05/98–10/00



Wed Sep 4 13:57:23 2002

FREQUENCY AND SPEED BY DIRECTION

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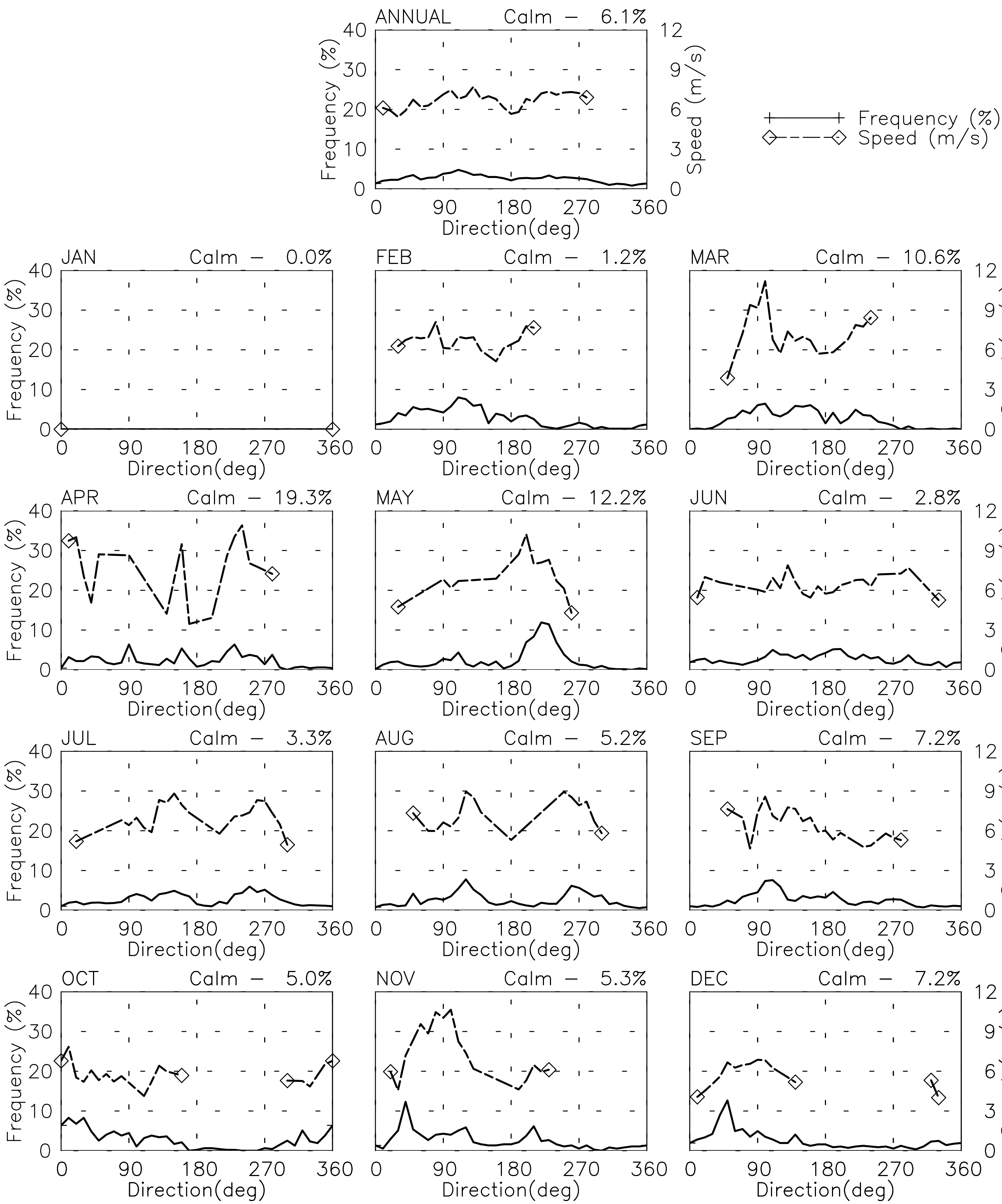
31° 31' N 121° 56' E – Elev 8m LST=GMT+99 hours *NT= +8

05/98–10/00



Wed Sep 4 13:56:59 2002

FREQUENCY AND SPEED BY DIRECTION

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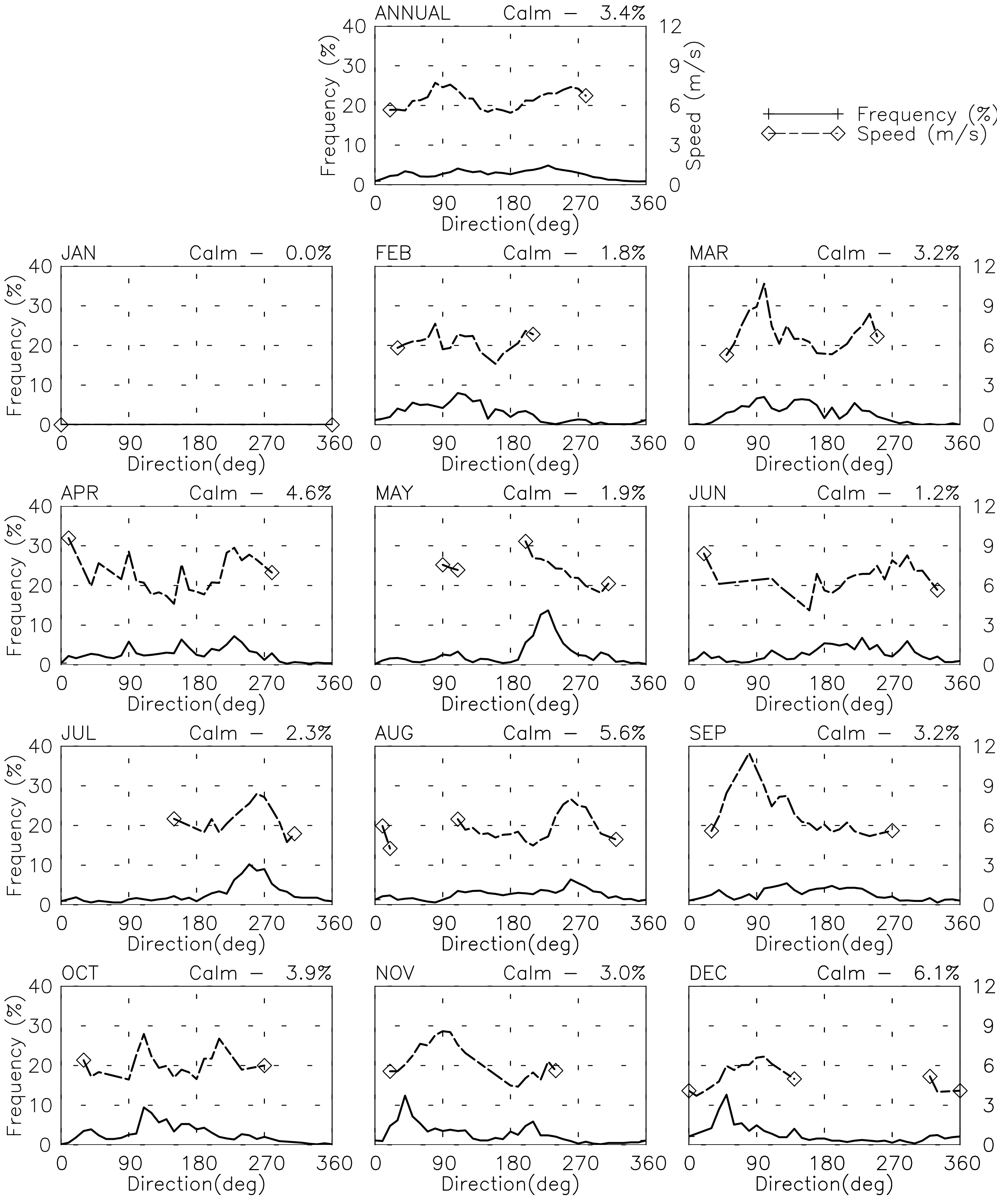
05/98–05/00



Wed Sep 4 13:57:13 2002

FREQUENCY AND SPEED BY DIRECTION

Dongwangsha 10m – 000032
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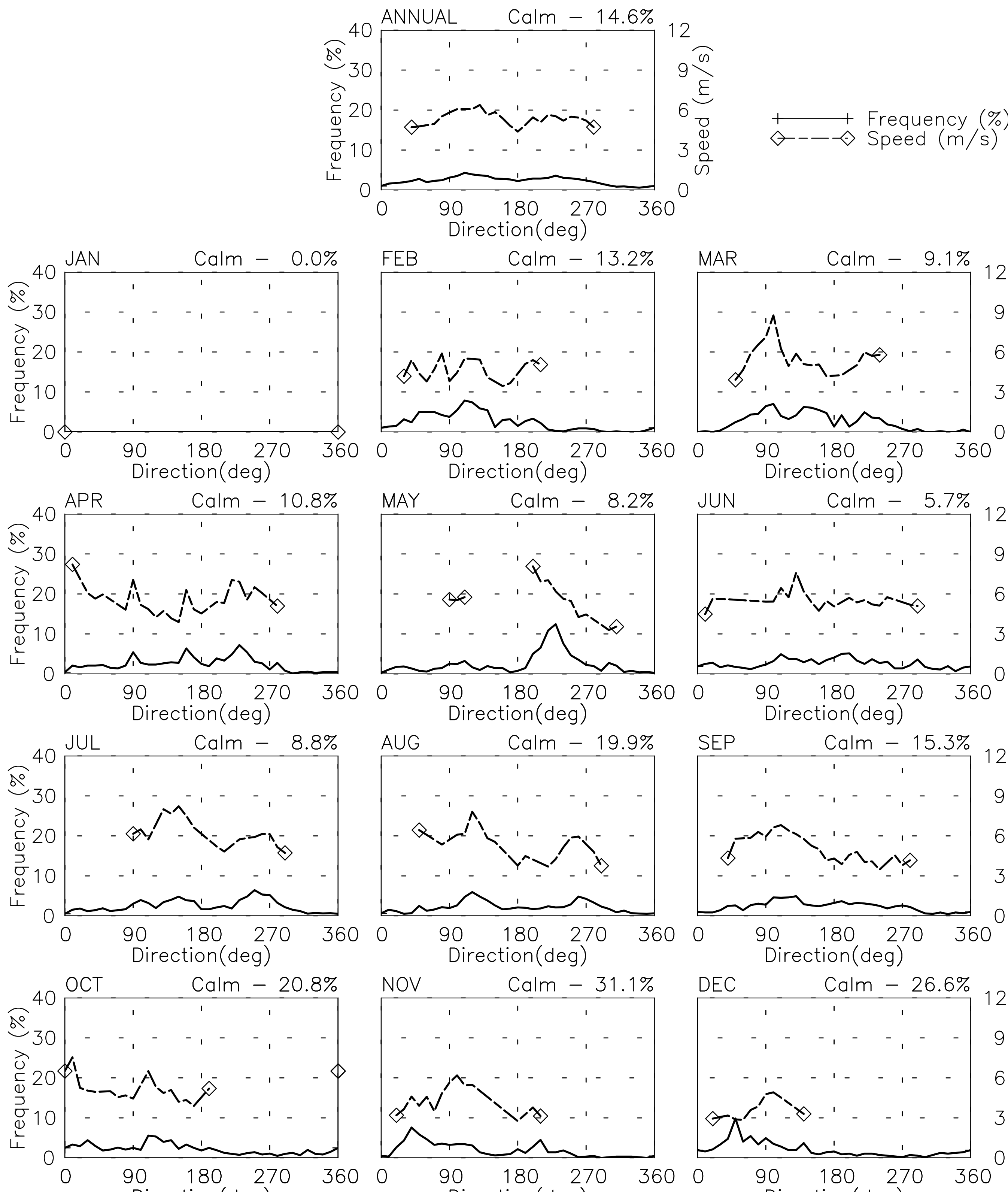
05/98–10/00



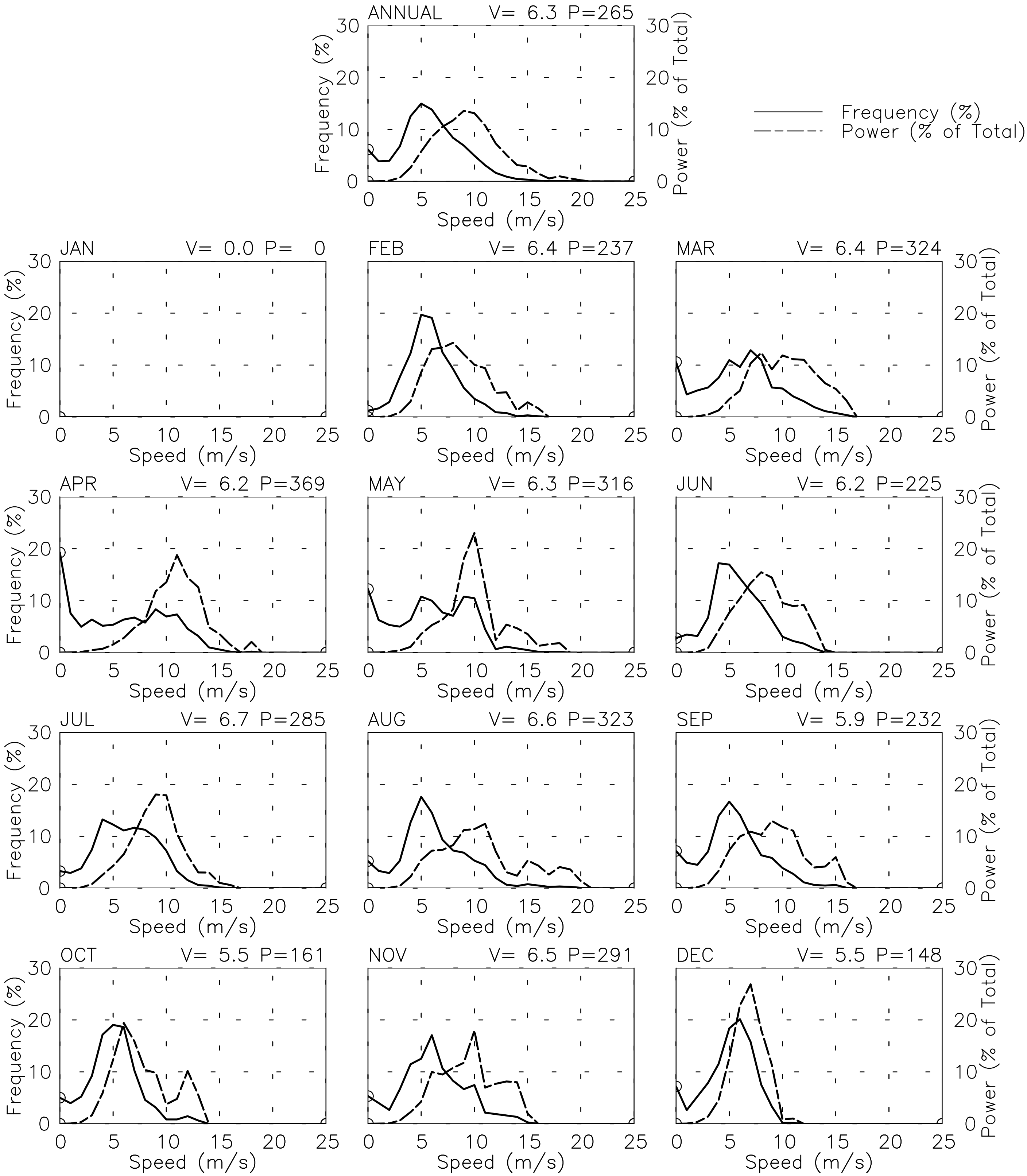
Wed Sep 4 13:57:26 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

Dongwangsha 50m – 000030

31° 31' N 121° 56' E – Elev 8m LST=GMT+99 hours *NT= +8

05/98–10/00



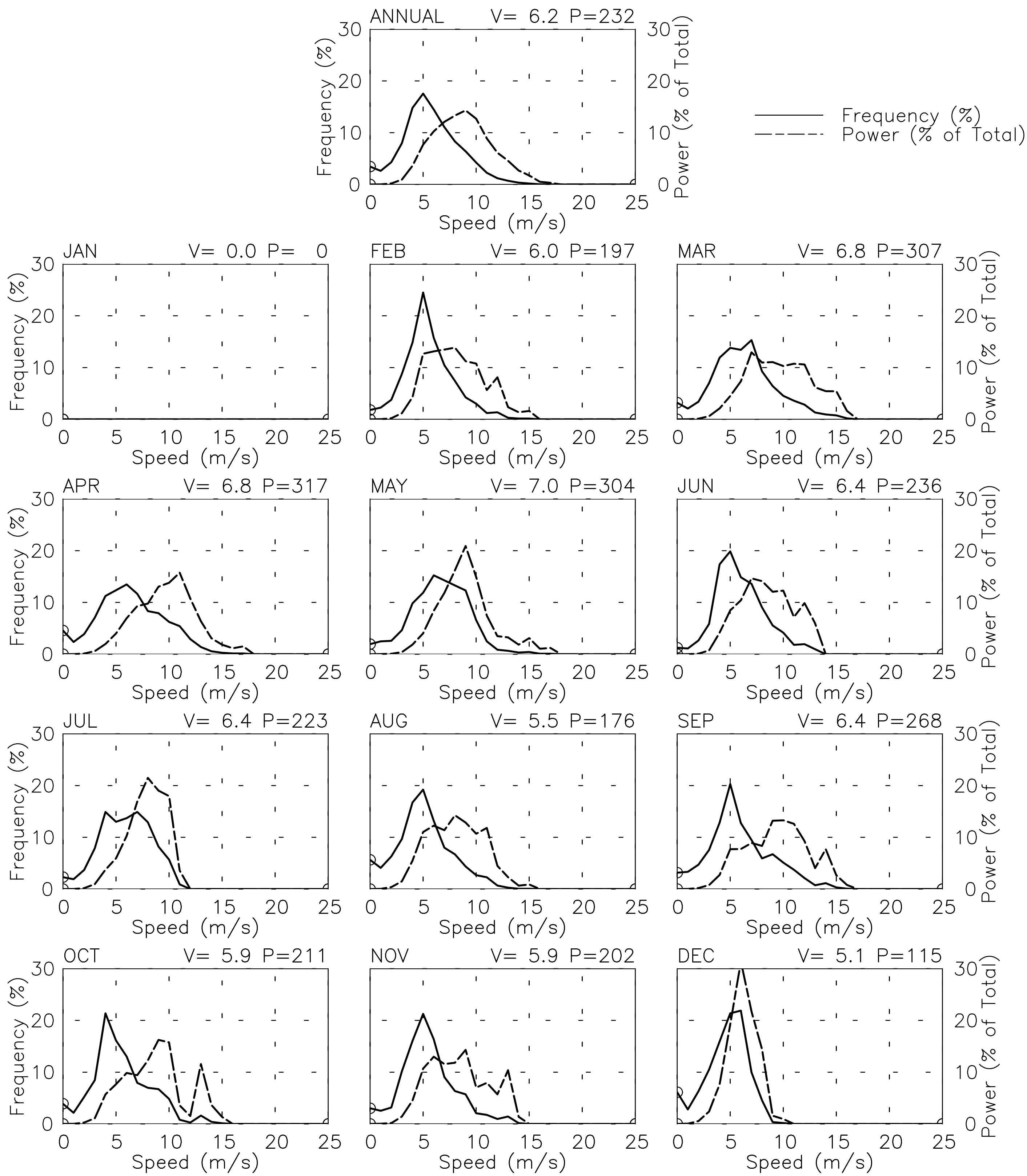
Wed Sep 4 13:57:02 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

Dongwangsha 40m – 000031

31° 31' N 121° 56' E – Elev 8m LST=GMT+99 hours *NT= +8

05/98–05/00



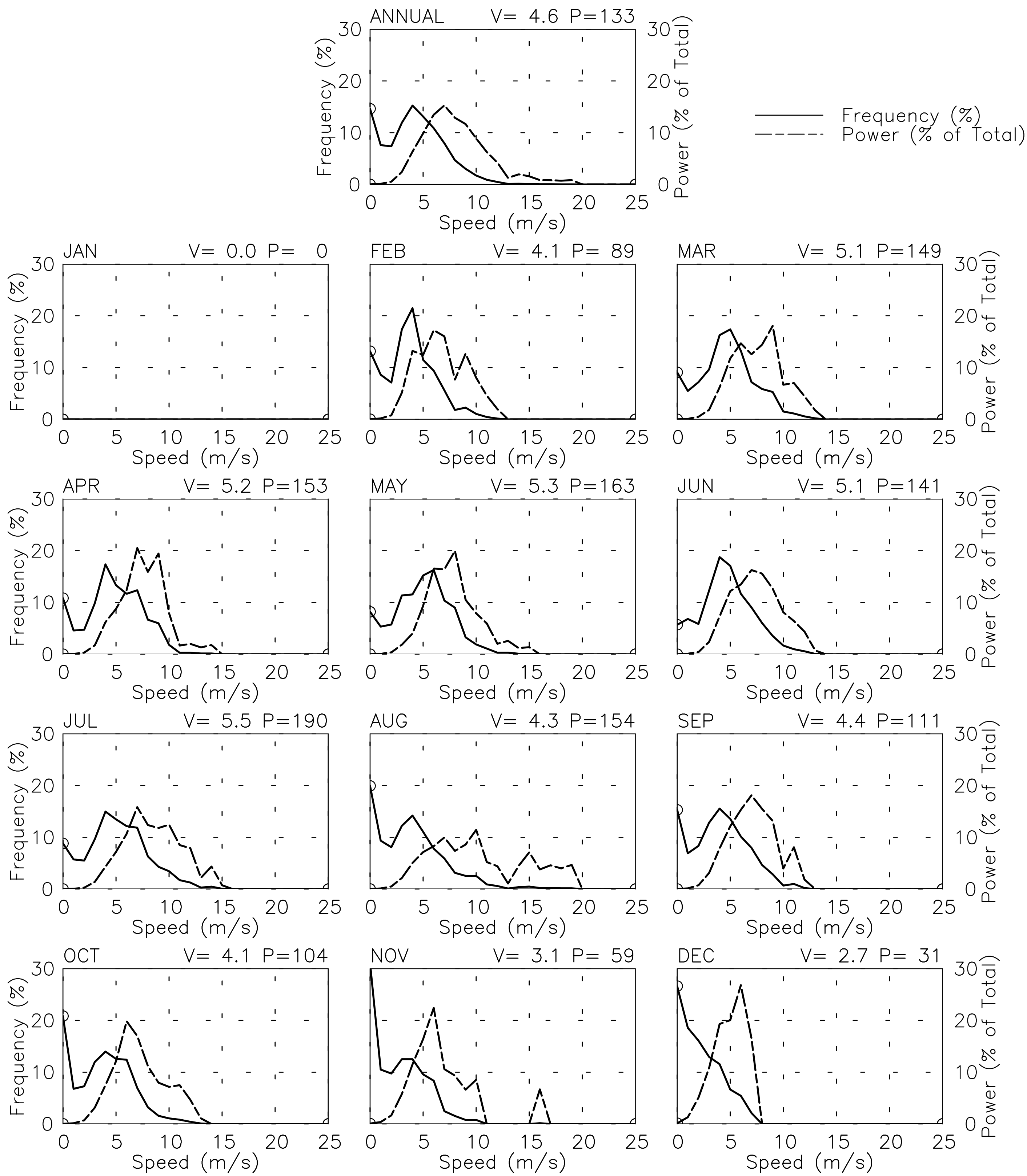
Wed Sep 4 13:57:15 2002

FREQUENCY OF SPEED & PERCENT OF POWER BY SPEED

Dongwangsha 10m – 000032

31° 31' N 121° 56' E – Elev 8m LST=GMT+99 hours *NT= +8

05/98–10/00



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D. Elliott, M. Schwartz, G. Scott, S. Haymes, D. Heimiller, and R. George

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13. ABSTRACT *(Maximum 200 words)*

This wind energy resource atlas identifies the wind characteristics and distribution of the wind resource in two regions of southeast China. The first region is the coastal area stretching from northern Fujian south to eastern Guangdong and extending approximately 100 km inland. The second region is centered on the Poyang Lake area in northern Jiangxi. This region also includes parts of two other provinces—Anhui and Hubei—and extends from near Anqing in Anhui south to near Nanchang in Jiangxi.

The detailed wind resource maps and other information contained in the atlas facilitate the identification of prospective areas for use of wind energy technologies, both for utility-scale power generation and off-grid wind energy applications. We created the high-resolution (1-km^2) maps in 1998 using a computerized wind resource mapping system developed at the National Renewable Energy Laboratory (NREL). The mapping system uses software known as a Geographical Information System (GIS).

14. SUBJECT TERMS
Southeast China; wind energy resource; atlas; Geographical Information System (GIS)

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